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TWO ESSAYS ON HOUSING: USING HEDONIC AND QUASI-EXPERIMENTAL METHODS IN (DIS)AMENITY VALUATION WITH HOUSING DATA: THE CASE OF COMMUNICATION ANTENNAS, AND THE VALUE OF BRAND NAME FRANCHISES COMPARED TO LOCAL REAL ESTATE BROKERAGE FIRMS

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DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Business and Economics
at the University of Kentucky

By
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Lexington, Kentucky

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ABSTRACT OF DISSERTATION

TWO ESSAYS ON HOUSING: USING HEDONIC AND QUASI-EXPERIMENTAL METHODS IN (DIS)AMENITY VALUATION WITH HOUSING DATA: THE CASE OF COMMUNICATION ANTENNAS, AND THE VALUE OF BRAND NAME FRANCHISES COMPARED TO LOCAL REAL ESTATE BROKERAGE FIRMS

This dissertation consists of two essays on housing, the first on estimation strategies for the valuation of a local disamenity and the second on the structure of the market for the services of real estate brokers.

The purpose of the first essay is to apply hedonic and quasi-experimental methods to measure the value of any disamenity caused by communication antennas. Crucial to unbiased estimates is accounting for both endogenous antenna location and changes in unobservable housing and neighborhood characteristics. Spatial fixed effects are used to control for unobservable characteristics that can influence the location decisions of residents and the location of antennas. Panel data techniques are used to address both time invariant and time varying unobservables and to account for possible changes in the hedonic price function after construction of a nearby antenna. The estimates indicate that houses near communication antennas sell less than comparable houses not located near a communication antenna, and also highlight a shortcoming of applying the difference-in-differences technique to value a local disamenity when houses are affected by the presence of multiple sites.

The second essay compares the performance of brand name franchised and independent real estate brokers with respect to list price, sales price, time on the market, and prevalence in areas with more out-of-state buyers using techniques that control for the different types of agents that choose to affiliate with franchised real estate brokerage firms. The results indicate that most of the difference in the sales price and the time it takes to locate a buyer can be explained by the types of agents that choose to affiliate with franchised brokerage firms, and that on average weaker agents choose to affiliate with franchised real estate firms. In addition, there is an indication that properties in areas with larger shares of out-of-state residents are more likely to be sold by a franchised broker. This result is consistent with the industrial organization literature on franchising that says franchising should be more prevalent in areas where consumers are less familiar with the local market.

KEYWORDS: Hedonics, Housing, Non-Market Valuation, Franchising, Firm Behavior

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August 8, 2013
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This dissertation is dedicated to my parents, Barry and Shirley, and to my brother Daniel. Without their love and support, this work would not have been possible.

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1 Introduction

Housing markets contain a vast amount of information that is valuable to both economists and policy makers. Whether it is the percentage of owner-occupied units, the number of foreclosures, or the number of new construction starts, housing markets are often analyzed to determine the health of our economy. A less discussed aspect of housing markets is their usefulness in valuing goods and services that are not explicitly traded in formal markets. This dissertation uses information revealed in the housing markets in the Louisville and Elizabethtown areas in Central Kentucky to estimate the disamenity value associated with communication antennas and the value of using franchised real estate brokerage firms.

Using the equilibrium framework developed by Rosen (1974), and econometric advances of the subsequent 39 years, the first essay estimates the disamenity value associated with communication antennas located near residential properties. Surprisingly, this topic has received little attention in the economics literature. As the demand for cell phones and mobile technology increases, it is followed by an increase in demand for reliable coverage, which in turn leads to an increase in the number of antennas. A recent article by Alcantara (2012) with AOL Real Estate highlights the concerns residents have about having a communication antenna located near their property. As reported, a group of residents in Mesa, Arizona are protesting the siting of a cell phone tower in their neighborhood. One resident is quoted as saying "apart from the tower being so tall, we all feel that property values will go down if they build it so close. Most people I know wouldn't want to buy a house near a cell phone tower." This essay combines detailed house sales data combined with data from the Federal Communication Commission's Antenna Structure Registration Database to determine resident's willingness to pay to avoid living near communication antennas.

Omitted variables are a constant concern when estimating hedonic price functions. Following Rosen (1974), the hedonic price function of property i can be represented by $P_i = P(S_i, N_i, Q_i)$ where P_i is the price of property i. S_i, N_i, and Q_i are the structural, neighborhood, and environmental characteristics, respectively. Once the hedonic price function P_i has been estimated, the partial derivative of P_i with respect to the environmental characteristic Q_i is equal to the implicit price of the environmental characteristic. However, when there are characteristics unavoidably omitted from P_i that are correlated with Q_i, the estimate of willingness to pay for Q_i will be biased. Endogeneity in the location of the antenna structures is the greatest concern in estimation. Holding all else constant, owners of the antenna structures are going to locate them in areas where it costs the least. If not taken into account, this incentive will lead to an overestimate of the negative impact these structures have on property values. Following the recommendation of Kuminoff et al. (2010), spatial fixed effects are used to control for any time invariant unobservables that are correlated with proximity to an antenna, and panel data techniques are used to address time invariant and time varying unobserved characteristics that could affect the equilibrium hedonic price function.

The data used contain over 140,000 transactions over a period of 12 years, and contain over 20,000 properties that are sold at least twice during the sample period. The data contain the list and sales price, an extensive set of structural characteristics, and precise location information for each sold property. These data are much richer than data extracted from a local Property Valuation Administrator or data from DataQuick that are commonly used to value localized disamenities. First, they are actual sales data that are recorded by the real estate agent that listed the property. Second, the extensive set of structural characteristics reduces the number of omitted variables that could potentially be correlated with proximity to a communication antenna. Lastly, the data contain the structural characteristics at the time of each sale so the assumption that structural characteristics

remain constant when a house is sold more than once can be relaxed. The richer data enables estimation that overcomes econometric issues that limited previous studies.

First, regressions are estimated that rely on cross-sectional variation in distance to the nearest antenna and do not exploit the panel aspect of the data. The precise location information contained in the dataset allow for the inclusion of spatial fixed effects that will absorb the effect of any time-invariant unobservables that are correlated with proximity to a communication antenna. Proximity measures are included that allow the effect communication antennas have on property values to vary with distance. These include a quadratic in distance to the nearest antenna, the inverse of distance to the nearest antenna, distance bands that indicate whether or not an antenna is located within a specified radius from the property, and distance bands that count the number of antennas within a specified radius from the property. The second set of regressions exploits the panel aspect of the data to reduce the potential bias caused by time invariant unobservables. These regressions include the repeat sales and difference-in-difference specifications.

The best estimate of reduction in sales price caused by communication antennas comes from the the cross-section specification that includes census block group fixed effects and holds constant the the number of antennas that are located near each house. These estimates show that a house within 1,000 feet of the nearest antenna when it is sold will sell for 1% ($1,836) less than a similar house that is 4,500 feet from the nearest antenna. Consistent with Kuminoff et al. (2010), the estimates from the repeat sales specification confirm that the spatial fixed effects captured the effect of any time-invariant unobservables that were spatially correlated with distance to the nearest antenna in the cross section specifications. The quasi-experimental results highlight a shortcoming of applying the difference-in-differences technique to estimate the value a local disamenity when houses are affected by the presence of multiple sites.

Using the same data as essay 1, the second essay compares the performance of franchised and independent real estate brokerage firms. The data identify the listing and selling firms and agents for each sold property and allow for the first comparison of franchised and independent real estate brokers using house level sales data. Previous studies on franchising in real estate brokerage have relied on aggregated survey data and focus on the cost effectiveness and profitability of franchised and independent real estate brokerage firms. This essay compares the different types of brokers in terms of the list price, the sales price they are able to get for the homeowner, the length of time it takes to locate a buyer, and their prevalence in areas where home buyers are less familiar with the local market.

A model of real estate brokerage is developed that takes into account the differences between franchised and independent real estate brokerage firms. This model builds upon the model of discount brokerage presented in Rutherford and Yavas (2012) by relaxing assumptions about the contest success functions that relate the efforts exerted by real estate brokers to the probability of locating a buyer for a listing. The model also extends the model presented in Rutherford and Yavas (2012) by allowing there to be n selling agents so that the effort levels of the listing and selling brokers can be compared when there are multiple brokers competing to locate a buyer. The model provides two testable hypotheses. The first is that houses listed with franchised and independent brokers will have the same list price for a given house, and the second is that franchised brokers sell their own listings less often than independent brokers. Each of these hypotheses are tested using the detailed sales data discussed earlier.

Brokers that choose to affiliate with a real estate franchise gain access to a unique set of benefits that are not available to brokers who choose to work for an independent firm. For example, real estate brokers that choose to affiliate with franchise have access to extensive training resources, referral networks, and lead generating systems that brokers who choose to start an independent company do not have access to. Because of this, homeowners who

choose to list their house with a franchised listing broker may benefit from having their house sold sooner if these benefits allow franchised brokers to more efficiently match buyers and sellers. However, a quicker sale may not always be ideal if it is at the cost of a lower sales price. These benefits also give weaker and less experience agents an incentive to affiliate with a franchise to increase their productivity while establishing themselves in the real estate industry. The tradeoff between the sales price and length of time it takes to locate a buyer will be estimated using the method from Levitt and Syverson (2008) and accounts for the possibility that franchised and independent brokerage firms may perform differently simply because of the types of agents who choose to affiliate with each type of firm. This is something that previous studies on franchising in real estate brokerage have not been able to do.

One of the most commonly discussed reasons for franchise affiliation is that association with a franchise gives the franchisee access to a highly recognizable brand name that serves a signal of quality (Rubin, 1978; Brickley and Dark, 1987; Frew and Jud, 1986; Anderson and Fok, 1998). If people are moving into an area where they are unfamiliar with the local housing market and the quality of real estate brokerage firms in the area, they may choose to work with a franchised real estate broker if they associate the brand name with a certain level of quality. Brickley and Dark (1987) argue that in general consumers less familiar with the local market will choose a franchise if they associate the franchise with a certain level of quality, while Frew and Jud (1986) and Anderson and Fok (1998) make the same argument specifically for real estate brokerage services. Access to a recognizable brand name may provide weaker and less experienced agents even more incentive to affiliate with a real estate franchise. The precise location information for each house in the sample is used to estimate the number of out-of-state buyers that are located in the census tract in which each house is located that serves as a measure of familiarity with the local real estate market. This essay is the first to use housing sales data to test the

hypothesis that franchising should be more prevalent in areas where consumer are less familiar with the local market.

Results for the test of the theoretical models predictions show that franchised listing brokers do sell their own listing less often, as expected, but that houses listed with franchised brokers are listed for less than comparable houses listed with independent brokers. This result is unexpected and suggests that franchised brokers may be strategically underpricing houses in order to get them off the market sooner. When franchised and independent brokers are compared in terms of the sales price they are able to get for the homeowner and the length of time it takes to locate a buyer, the results suggest that most of the difference can be explained by the agents who affiliate with a franchised broker. The results also suggest that on average, weaker agents are the ones who chose to affiliate with a franchise. Lastly, the results show that franchised selling brokers are more active in areas where consumers are less familiar with the local real estate market.

Overall, this dissertation strives to contribute to the body of knowledge about using information revealed in housing markets to value a localized disamenity and to compare the value of choosing franchising as an organizational form. First, the dissertation demonstrates how detailed sales data can be used to overcome econometric issues related to time invariant spatially correlated unobservables. Second the dissertation demonstrates how real estate firms that choose franchising as an organization form compare to independent brokerage firms after controlling for differences in the types of agents that choose to affiliate with franchised real estate brokers. Lastly this dissertation shows that franchising is more prevalent in areas where a higher percentage of the residents are less familiar with the local market; this is the first known study to show this using housing

market data.

2 Using Hedonic and Quasi-Experimental Methods in (Dis)Amenity Valuation with Housing Data: The Case of Communication Antennas

2.1 Introduction

Cell phone usage worldwide and especially in the United States is growing faster than ever. In December of 1997 it was estimated there were 55.3 million wireless subscribers. Fifteen years later in December 2012, that number was estimated to be 326.4 million (CTIA-The Wireless Association (2013)). To put this in perspective, the United States Census Bureau estimated the population to be 267.8 million in 1997 and 319.9 million in 2012. This means the United States has gone from 20.6% of the population having a wireless subscription in 1997 to more than one subscription per individual in 2012. With the advances in mobile technology it is possible to do nearly every task that was once only possible on a desktop computer on a mobile device that fits in the palm of a hand. Like any other good or service, the added convenience of mobile technology has costs.

An area that has received little attention in the economics literature is the disamenity associated with the structures on which these antennas are mounted. As the demand for cell phones and mobile technology increases, it is followed by an increase in demand for reliable coverage, which in turn leads to an increase in the number of antennas. Beginning in the mid-1990's there was a sharp increase in the number of antenna structures which roughly corresponds to the time when mobile phone technology became more prevalent. Choosing the location for an antenna involves conflicting incentives for residents. Land owners may want to have an antenna located on their property since it provides an additional source of income and better cell phone reception for residents in its vicinity[1]. However, these structures are not pleasant to look at and residents tend to object to having them located nearby because of the visual disamenity they create or because of any

[1] Airwave Management LLC. provides some insight into the amount of income these cell phone towers can generate for a land owner. According to their website, payments can reach as high as $60,000 per year.

adverse health effects they associate with the antennas[2].

Figures 2.1a and 2.1b illustrate when an externality is likely to exist, and the situation when a nearby antenna could provide a net benefit to nearby residents. In Figure 2.1a, an antenna is located on a property adjacent to a residential subdivision. Regardless of any compensation, the antenna structure is likely to be considered a disamenity by nearby residents[3]. Figure 2.1b shows an antenna that could provide a net benefit to nearby residents. The structure located at point A is hidden behind a thicket of trees and far enough away from the nearest neighbor (point C) to impose any cost. If the owner of the property at point B owns the land where the antenna is located, the owner is receiving payments from the antenna's owner, while nearby residents receive the benefit of improved coverage. In this situation the potential disamenity is mitigated by trees. Having an antenna located nearby should not decrease property values; it probably increases property values where the antennas are located.

The purpose of this paper is to apply hedonic and quasi-experimental methods to measure any disamenity caused by communication antennas controlling for endogenous antenna location and changes in unobserved housing and neighborhood characteristics. Spatial fixed effects are used to control for any time invariant unobservables that are correlated with proximity to an antenna. The repeat sales method and quasi-experimental techniques are used to address time invariant and time variant unobserved characteristics that could affect the equilibrium hedonic price function. Quasi-experimental techniques are

[2]Despite concerns about negative health effects from the radio waves emitted from mobile devices, a comprehensive study of the health effects related to cell phone and cell phone antennas by Röösli et al. (2010) finds that there is no conclusive evidence that using cell phones or living near cell phone towers harms human health. Nevertheless, the perception of such risks may be sufficient to alter ones behavior.

[3]If the structure was constructed *before* the residents moved in or built a house in this subdivision, no uncompensated externality exists. They have preferences such that the structure does not affect them, or they were compensated for the visual aspect of the structure though a lower purchase price. However, if the structure was constructed *after* the residents moved in or built in this subdivision, they are affected by the sight of the structure and a lower sales price if they do decide to sell the property. The land owner where the structure is located is receiving payments from the antenna's owner, while all affected nearby residents are not being compensated.

becoming increasingly common in the environmental economics literature and are used instead of instrumental variables when there is not random assignment into treatment and control groups(Greenstone and Gayer, 2009).

2.2 Recent Work on Valuing Amenities/Disamenities

Omitted variables are a constant concern when estimating hedonic price functions. Following Rosen (1974), the hedonic price function of property i can be represented by $P_i = P(S_i, N_i, Q_i)$ where P_i is the price of property i. S_i, N_i, and Q_i are the structural, neighborhood, and environmental characteristics, respectively. Consumers have utility $U = U(X, S_i, N_i, Q_i)$ which is maximized subject to the budget constraint $P_i + X = M$, where X is a Hicksian composite commodity with price equal to \$1, and M is income. This gives the following first order condition:

$$(\partial U/\partial Q_i)/(\partial U/\partial X) = \frac{\partial P_i}{\partial Q} \tag{2.1}$$

This says the marginal rate of substitution between the environmental characteristic and the composite good X is equal to the slope of the hedonic price function (market clearing locus) in the environmental characteristic Q_i. Once the hedonic price function P_i has been estimated, the partial derivative of P_i with respect to the environmental characteristic Q_i is equal to the implicit price of the environmental characteristic. However, when there are characteristics unavoidably omitted from P_i that are correlated with Q_i, the estimate of willingness to pay for Q_i will be biased. Endogeneity in the location of the antenna structures is the greatest concern in estimation. Holding all else constant, owners of the antenna structures are going to locate them in areas where it costs the least. If not taken into account, this will lead to an overestimate of the negative impact these structures have on property values. Other issues that have to be addressed in estimation concern buyers sorting and the stability of the hedonic price function. To address the sorting concern,

spatial fixed effects are included to control for unobservables that may influence both buyer's location choices and the location of communication antennas. The most recent panel data techniques that address both time-invariant and time-varying unobservables are used to account for the possibility of a changing hedonic price function after the construction of a nearby antenna.

Rosen (1974) makes two critical assumptions in his characterization of the hedonic equilibrium. The first is that buyers have complete information about their available alternatives. In the study of housing markets, this implies that consumers have perfect information about local amenities and disamenities. Currie et al. (2013) check this assumption by estimating the external costs associated with the opening and closing of toxic industrial facilities. They compare the willingness to pay to avoid these facilities (estimated using housing data) to the costs associated with the increased incidence of children born with low birth weight caused by the same toxic facilities. They estimate an aggregate reduction in housing values per plant of $1.5 million within a one mile radius, and costs associated with the increased incidence of low birth weight of about $700,000. Since the reduction in property values reflect the costs associated with adverse health effects along with factors such as increased congestion, the visual disamenity associated with the facilities, decreased utility from outdoor activity, they conclude that the evidence fails to contradict the assumption of unbiased or perfect information in the housing market. Since the disamentiy associated with communication antennas is visual, and the antenna structures are highly visible, the assumption of full information is appropriate for this study.

The second assumption is that households move freely among locations, and that consumers have homogeneous preferences over the bundle of goods being purchased. Cameron and McConnaha (2006) find evidence that households do migrate in response to perceived changes in environmental conditions. Bayer et al. (2009) find that the estimates

of willingness to pay for a reduction in ambient concentrations of particulate matter that incorporate the cost of moving are three times greater than the estimates from a conventional hedonic model using the same data. Bieri et al. (2012) use the 5% public use sample from the 2000 Census that contain the housing prices, wages, and location specific amenities for over 5 million households to estimate aggregate amenity expenditures for the United States. The precise household level data allow them to relax the assumption of homogeneous households and to precisely estimate the cost of moving between possible locations. Their preferred estimates come from a specification that uses historical migration data for each location to identify a consideration set of possible locations for each household combined with location to location specific moving costs. They show that the estimates of aggregate amenity expenditures are sensitive to the way in which migration is modeled. Kuminoff et al. (2012) provide an overview of the current state of the equilibrium sorting literature housing markets. All four of these studies suggest that estimates of disamenity value should consider migration, sorting, and changes over time.

While Rosen (1974) show that the partial derivative of P_i with respect to Q_i provides an estimate of the willingness to pay for a small change in the environmental good Q_i, the appropriate functional form for the hedonic price function is uncertain. Cropper et al. (1988) use simulations to see determine how different functional forms perform when there are omitted variables in the hedonic price regression. They find that flexible function forms perform well when all of the attributes are included, but recommend using a more parsimonious function forms when there are omitted variables. The linear, semi-log, double-log, and linear Box-Cox functional forms have remained the most prevalent functional forms used to estimate the marginal willingness to pay for environmental amenities to reduce bias caused by omitted variables.

Since Cropper et al. (1988), sample sizes have increased dramatically, advances in geographical information systems allow researchers to control for previously unobserved

spatial characteristics, unobserved structural housing characteristics are much less of a concern, and quasi-experimental techniques have become more prevalent. Kuminoff et al. (2010) use a theoretically consistent Monte Carlo framework to test the performance of six functional forms when time-varying and time-constant spatial variables are omitted. After addressing advances, Kuminoff et al. (2010) find that the recommendations in Cropper et al. (1988) should be reconsidered. When using cross-section data, Kuminoff et al. (2010) find that the quadratic Box-Cox functional form with spatial fixed effects performs best. However, for practical purposes, including spatial fixed effects significantly reduces bias regardless of the functional form used[4].

Kuminoff et al. (2010) also show that exploiting variation in an environmental amenity for properties that sell multiple times can reduce bias in willingness to pay estimates compared to pooled OLS with fixed effects. If the spatially correlated unobservables are time invariant, their effect will be purged from the model when first differences are taken. However, if the unobservables are not time invariant, the estimates from a repeat sales model will be biased. Repeat sales models have recently been used to estimate the impact of changing cancer risks (Gayer et al., 2002), the siting of wind farms (Heintzelman and Tuttle, 2012), Superfund site remediation (Mastromonaco, 2011), and reductions in three of the Environmental Protection Agency's criteria air pollutants (Bajari et al., 2012).

Kuminoff et al. (2010) find that a generalized difference-in-difference estimator with interactions between the time dummy variables and housing characteristics to allow the shape of the price function to change over time performs the best when panel data are available. Linden and Rockoff (2008) provide a technique for defining treatment and control groups so that difference-in-differences can be used to estimate the impact of environmental (dis)amenities when treatment and control groups are not clearly defined. They used this technique to define treatment and control groups to estimate the

[4]Since the quadratic Box-Cox is still computationally intensive and the coefficients are difficult to interpret, semi-log and linear Box-Cox models are commonly used.

willingness to pay to avoid living near a registered sex offender. Their technique has recently been used to estimate the impact of brownfield remediation (Haninger et al., 2012) and shale gas developments (Muehlenbachs et al., 2012)[5]. Parmeter and Pope (2012) provide a thorough overview of difference-in-difference method and other quasi-experimental techniques. By differencing over time, the difference-in-difference method controls for time invariant unobservables just like the fixed effects and repeat sales methods, but also overcomes problems with time-varying unobservables with the "common trends" assumption. While this assumption cannot be formally tested, Linden and Rockoff (2008) provide visual evidence that it holds in their study. Once treatment and control groups are defined, they plot housing prices against the days relative to a sex offender's arrival. Since prices in the control group trend similarly before and after offenders arrive, but prices in the treatment group fall significantly, they are confident they have identified a valid control group. A similar approach will be used here[6].

Hedonic property value models are used to estimate the marginal willingness to pay for environmental amenities, $\partial P_i/\partial Q$. While there are advantages of using the repeat sales method and quasi-experimental techniques to eliminate the bias caused by time-invariant unobservables, these methods estimate a capitalization rate that is not necessarily equal to the marginal willingness to pay. It is possible that the presence of, or change in an environmental (dis)amenity can cause the hedonic price function to change over time. Kuminoff and Pope (2012) and Haninger et al. (2012) show that as long as the hedonic price function is constant over time, there should be no difference between the

[5]Muehlenbachs et al. (2012) use a difference-in-difference-in-differences model. They use the Linden and Rockoff (2008) technique to find the distance at which shale gas developments do not impact property values, but also use the local public water service area to define a second treatment group. Similar to owners of land where shale gas wells are drilled, owners of land where communication antennas are located receive payments from the antenna's owner. Assuming that conditional on a property's observable characteristics and being within 2000 meters of a drilled well, every property has an equal chance of receiving lease payments regardless of water source, they are able to separate the impact of lease payments and decreased water quality.

[6]In this study, a majority of communication antennas were built several years before the property is sold making a visual check of the "common trends" assumption difficult.

capitalization rate and the marginal willingness to pay. Given that the communication antennas are expected to have relatively small impacts on property values, it is unlikely that the construction of a new antenna structure will lead to a change in the hedonic price function. But, this issue will be addressed.

Mastromonaco (2011) and Bajari et al. (2012) both propose methods for reducing bias caused by time-varying spatially correlated unobservables. Mastromonaco (2011) includes census tract-year fixed effects that allow the effect of unobservables at the neighborhood level to vary over time in a repeat sales model. Bajari et al. (2012) also use a repeat sales model, but exploit information contained in the residual from the first sale to learn about the characteristics of the house that the researcher cannot observe directly. Specifically, they argue that after controlling for the characteristics that are observable, if the sales price was abnormally positive (negative) the first time it was sold, this value of the characteristics that were not observed is positive (negative). They show that not controlling for time-varying unobservables leads to estimates of willingness to pay for reductions in air pollution that are considerably smaller than when these unobservables are considered. Bajari et al. (2012) are not able to control for changes in house characteristics directly because they have characteristics for the last sale only. In contrast the data used in this study has house characteristics at the time of each sale and allows for control of changes in them. The results below show that the unobservables that are correlated with proximity to a communication antenna are time invariant and are adequately controlled for using spatial fixed effects.

2.3 Data on Housing and Antennas

Housing data cover a period of 12 years from 2000 to 2011 and were extracted from two Multiple Listing Services that serve the Louisville and Elizabethtown areas in central Kentucky. The housing data contain an extensive set of structural housing characteristics,

closing dates, and sales price for every property sold. All property addresses were geocoded using a program that accessed MapQuest and provided a standardized address and latitude and longitude for each property[7]. This standardized address is used to identify houses that are sold multiple times.

These data are much richer than data extracted from a local Property Valuation Administrator or data from DataQuick that are commonly used. While data from each of those sources identify properties that are sold more than once, the structural housing characteristics are only recorded for the most recent transaction. The data used here identify properties that are sold more than once during the sample period and record the structural housing characteristics each time the property is sold. This detail allows for a check of the assumption that structural housing characteristics are constant over time, an assumption that is often made when using the repeat sales method.

Data for the communication antennas come from the Federal Communication Commission's (FCC) Antenna Structure Registration database. This database includes all communication antennas in the United States that are registered with the FCC. All antennas that may interfere with air traffic must be registered with the FCC to make sure the lighting and painting requirements are met. These data contain antenna characteristics such as dates for construction and demolition, latitude and longitude, antenna height, and antenna type. It is possible there are antennas located in the study area that are not registered, but this is rare. Since the construction date for each antenna needs to be known to ensure the antennas located near houses were standing when the property sold, antennas that did not include a construction date were dropped[8]. In this study, data cover a large

[7]One issue with geocoding addresses is that the coordinates will correspond to the location on the street where the property is located and not the exact coordinates of the actual house; Filippova and Rehm (2011) were able to overcome this using the coordinates where the home was located within the plot. In the current study, properties that were not assigned a standardized address and a unique latitude and longitude were excluded from the final sample. Properties with less than 500 square feet or more than 10,000 square feet or zero bedrooms or zero full baths were also dropped.

[8]Since the earliest construction year in the sample of antennas is 1927 and the latest 2011, it cannot be

area. Google Earth was used to verify whether or not an antenna was standing when the property sold if there was a dismantled date recorded. Since the images include the date the image was captured, it was possible to identify whether or not the antenna was standing when the property sold[9].

ArcGIS was used to determine several location-specific characteristics. They include (1) the census tract in which each house is located, (2) the census block group in which each house is located, (3) distance to the nearest communication antenna, (4) distance to the nearest parkway/interstate, (5) distance to the nearest railroad, and (6) distance to the Fort Knox military base. Since the visual disamenity of communication antennas is the focus of this study, all proximity measures were calculated using straight line distances. All antennas within a ten mile radius of each property that were standing when the property was sold were identified. This information was used to determine the number of antennas located within specified distances from each property.

Summary statistics for the housing characteristics are given in Table 2.1. The typical house sold for $183,619, has three bedrooms, two full bathrooms, is 1,655 square feet in size, has a lot size of about eight-tenths of an acre, and is 33 years old. Holding all else constant, the owner of a communication antenna will attempt to locate the antenna in an area that minimizes the owner's cost. To check if antennas are located in areas where property values are low to begin with, Table 2.2 shows summary statistics for houses within and beyond 4,500 feet of an antenna[10]. Houses within 4,500 feet of an antenna sell for $32,979 (16%) less than a house more than 4,500 feet away, have slightly fewer bedrooms and bathrooms, are smaller, and are on smaller lots. The most notable

assumed that the absence of a construction date means the antennas with missing dates were built before the year 2000 and can be included in the final sample.

[9]This was a concern for only a handful of antennas. Multiple antennas were assigned the same coordinates and it was determined that this corresponded to multiple antennas being mounted on the same structure. Some demolition dates indicated that an antenna was removed, and some demolition dates indicated that the actual structure was taken down. Being dismantled refers to the latter.

[10]4,500 feet is approximately the median value of distance to the nearest standing antenna in this sample.

difference is that houses within 4,500 feet of an antenna are about 18 years older on average than houses more than 4,500 feet away from an antenna. It appears that communication antennas are in fact located in areas where properties are less valuable. While most of the difference in sales prices for houses within and beyond 4,500 feet of a tower can be explained by differences in the types of houses, the primary focus of this study is controlling for differences that are unobservable. The precise location information for each house provided in the data is used to control for these unobservables[11].

Summary statistics for the proximity measures of all antennas are shown in Table 2.3[12]. The average house is located 5,794 feet (1.1 miles) away from the nearest antenna, with a median value of 4,500 feet (.85 miles). Only 0.6% of houses are within 600 feet of their nearest antenna, and 12.4% of the houses in the sample have antennas within 2,100 feet. The lower panel in Table 2.3 summarizes the number antennas that are located within certain distances from each house. While the majority of houses only have one antenna within each radius, there are are non-trivial number of houses that are likely affected by the presence of multiple antennas. For example, there are 204 houses that have two antennas within 1,500 to 1,800 feet, and 9 that have 3 antennas within that same radius. This means that estimating the disamentity value caused by communication antennas using distance to the nearest antenna could be biased due to the presence of multiple antennas. Estimates would tend to be biased upwards because all the value of the disamenity would be attributed to the nearest antenna when it should be attributed to the combination of antennas.

Before moving to estimation of any disamenity value of antennas, it is worth addressing

[11] A regression of the number of communication antennas in a census tract on the median sales price and census tract demographics suggest that the number of antennas in a census tract is negatively correlated with property values. However, even though the coefficient has the expected sign, the coefficient is not statistically different from zero at conventional levels, and the median sales price and demographics only explain 8% of the variation in the number of communication antennas in a census tract.

[12] Antennas refer to all of the structures in the sample regardless of their type. Towers refer to the largest type of structure that are the most visually disruptive due to their size and the distance at which they can be seen. Summary statistics for only tower type structures are shown in Table A1.1.

an overall concern about housing market analysis during the Great Recession. The concern is how an equilibrium framework such as that in Rosen (1974) can produce misleading results during a period of disruption[13]. Without question housing prices declined between 2006 and 2009, but as Carson and Dastrup (2013) report there was considerable spatial variation. Across metropolitan areas, housing prices declined none at all to more than 60%.

The four-quarter percent change in the Federal Housing Finance Agency's housing price index is shown in Figure 2.2 for the study area and the Los Angeles and Miami Metropolitan statistical areas (MSA). Even though the Louisville MSA was affected by the recent housing crisis, house prices remained relatively stable compared to the larger MSAs that were affected the most. This stability minimizes concerns that the results presented below are being affected by a rapidly changing and unstable housing market. Changes in demographic characteristics for the study from 2000 to 2010 are compared to changes for the entire United States in Table 2.4. The only notable difference is that unemployment more than doubled nationally while there was only a 62% increase in the study area. For the entire United States, the percent change in the number of people who moved from out of state fell by 71% while it increased by 12% in the study area; since the study area contains the Fort Knox military base, the above average number of out-of-state movers is to be expected[14].

[13]This issue is discussed in detail in Boyle et al. (2012).

[14]A regression of the change in the number of communication antennas in a census tract on the percent changes in demographic characteristic the same tract suggests that changes in demographics are not leading to significant changes in the number of communication antennas in an area. There were statistically significant coefficients on median income, unemployment, percent of the population that owns their home, and the percentage of the population with a bachelor's degree or higher. However, the changes in these characteristics required to cause one additional antenna to be constructed or dismantled are extremely large. For example, it would take a 1,067% increase in unemployment to lead to the dismantling of one antenna.

2.4 Empirical Model

To determine the impact proximity to an antenna structure has on property values, hedonic property value models and quasi-experimental methods are used. The first regressions rely on cross-sectional variation in distance to the nearest antenna and do not exploit the panel aspect of the data. The second set of regressions exploit the panel aspect of the data to reduce the potential bias caused by time invariant unobservables. The data cover a period of twelve years with communication antennas being built and dismantled throughout the period as well as in between sales of the same property. These changes allow for estimation of the traditional cross section specifications as well as the repeat sales and difference-in-difference specifications that are becoming more prevalent in the hedonic literature (Gayer et al. (2002); Linden and Rockoff (2008); Parmeter and Pope (2012); Haninger et al. (2012); Muehlenbachs et al. (2012); Bajari et al. (2012)).

2.4.1 Cross-Section Specification and Proximity Measures

Following Kuminoff et al. (2010) and Heintzelman and Tuttle (2012), a semi-log specification with spatial fixed effects is used to address the potential bias caused by time invariant, spatially correlated unobservables. The first specification is:

$$\ln P_{ijt} = z_{ijt}\beta + x_{ijt}\delta + \lambda_t + \gamma_j + \epsilon_{ijt} \tag{2.2}$$

where z_{ijt} is the set of variables describing proximity to the nearest antenna structures, x_{ijt} includes an extensive set of structural housing characteristics, λ_t are year-month time dummy variables, γ_j are spatial fixed effects, and ϵ_{ijt} is the error term. To demonstrate the importance of including the spatial fixed effects, equation (2.2) will be estimated without spatial fixed effects and again with census tract or census block group fixed effects. If there are unobserved spatial characteristics that are correlated with the proximity

variables, β in equation (2.2) should be more precisely estimated the tighter the fixed effect.

Three proximity measures are used that allow distance to a communication antenna to have a non-linear effect on the sales price of a house. The first is a continuous, quadratic measure of distance to the antenna nearest a property when it was sold[15]. By including distance and distance squared in the regression, the point at which an antenna has no effect on property values can be estimated. The spatial fixed effects ensure that this continuous measure of distance is measuring the impact of a nearby antenna and not proximity to an area that may be a magnet for communication antennas. As a robustness check, the inverse of distance to the nearest antenna that was standing when the property sold is also used.

The second measure is a set of dummy variables equal to one if the nearest antenna is located within some specified radius from the property and is similar the method used in Heintzelman and Tuttle (2012). Distance bands of 300 feet are used and the base category is the situation in which the closest antenna structure is more than 4,500 feet away. This specification allow for a discrete non-linear effect of distance to the nearest tower, however, there is no rule of thumb as to the width of distance bands that should be used or the distance from an antenna that should be used as the base category. Distance bands of 300 feet are used because they are sufficiently large to contain enough antennas to provide the variation needed to precisely estimate their effect, but small enough to allow for a higher degree of non-linearity than larger rings would allow. Houses more than 4,500 feet away from an antenna were chosen as the base category since this is the median value for distance to the nearest antenna.

The third measure uses the same 300 foot distance bands used in the previous method but counts the number of antennas located within a specified radius of the property.

[15]This method is used in Banfi et al. (2008), Bond (2007b), and Bond (2007a) to estimate the impact of cell phone towers on property values.

Mastromonaco (2011) uses this type of proximity measure to estimate the impact of Superfund sites on property values in Greater Los Angeles area of California. He points out that using the distance to the nearest site ignores the presence of additional nearby sites that could bias the results upward if only the nearest site is considered. By estimating the average impact of all nearby sites, some of the bias inherent in the nearest site method can be removed. If each house has only one antenna within a specified radius, this method would provide estimates identical to the nearest site method using dummy variables equal to one if an antenna is located within the specified radius. The summary statistics in Table 2.3 show that there are multiple properties that will be affected by the presence of multiple antennas. Including the number of antennas within in specified distance bands provides estimates of the marginal impact of adding one additional antenna within a specified distance, and this effect is allowed to vary with distance.

2.4.2 Panel Analysis - Repeat Sales and Difference-in-Differences

One strategy for removing time invariant unobservables is exploiting the variation in distance to the nearest antenna for properties that sell multiple times. During the study period, new antennas were constructed and old antennas were dismantled. This allows for variation in distance to the nearest antenna over time for the same property. This approach eliminates any time invariant unobservables that may be correlated with the proximity variables and is is the primary method used in Gayer et al. (2002), Heintzelman and Tuttle (2012), Mastromonaco (2011), and Bajari et al. (2012). The following regression is estimated:

$$\ln P_{it} - \ln P_{it'} = (z_{it} - z_{it'})\beta + (x_{it} - x_{it'})\delta + \lambda_t + \epsilon_{it} - \epsilon_{it'} \tag{2.3}$$

where z_{it} is the distance to the nearest standing antenna at time t, x_{it} are structural housing characteristics that may vary over time. Following Gayer et al. (2002), λ_t is a set of year

variables equal to -1 if the year indicates the first year the property sold, 1 if the year indicates the year of the last sale, and 0 for all other sales. This allows for appreciation in housing values over time. ϵ_{it} is the error term. This specification is different from the repeat sales model that is typically estimated. In the typical repeat sales model, only the proximity variables that measure distance to the nearest antenna would be allowed to vary over time while the structural housing characteristics are assumed to be constant. Some previous studies that use the repeat sales method use data from a source similar to this study and have housing characteristics at the time of each sale (Gayer et al., 2002). However, several recent studies use data from sources that do not record the structural housing characteristics each time a house is sold and make the assumption of constant structural characteristics (Heintzelman and Tuttle (2012); Mastromonaco (2011); Bajari et al. (2012)). The number of observations in the sample that have structural housing characteristics that change over time are shown in Table 2.5. Of the 26,579 houses that sold more than once, a non trivial number experienced a change in a major structural characteristic between sales. For example, 4,311 (17%) of houses had a change in the number of bedrooms between sales. Equation 2.3 will be estimated with and without the changing structural housing characteristics to control for changes and determine how sensitive the estimate of β is to the assumption of constant structural characteristics.

There are shortcomings when using the repeat sales approach. There is the possibility that the unobservables are not time invariant. Kuminoff et al. (2010) show that when the omitted spatial characteristics are time varying, the bias in the first differenced estimates increases substantially. Since not all properties are sold multiple times, the repeat sales approach leads to much smaller sample sizes. In addition, properties that sell multiple times may be systematically different than properties that only sell once. Properties that turn over multiple times may be repeatedly priced below market value, or more importantly, the local disamenity has an above average effect on those properties. With an

extensive list of housing characteristics at the time of all sales, the number of time varying unobservables is smaller than in a number of recent studies.

A second strategy for removing the influences of time invariant unobservables is discussed in detail in Parmeter and Pope (2012) and used in Linden and Rockoff (2008), Muehlenbachs et al. (2012), and Haninger et al. (2012) is difference-in-differences. A difficulty that arises when using difference-in-differences in a hedonic property value model is defining the treatment and control groups. To determine the distance at which communication antennas impact nearby property values, the method used in Linden and Rockoff (2008) will be used. Figure 2.3a illustrates the method used to define treatment and control groups in Linden and Rockoff (2008). The dashed line is the relationship between sales price and distance from a sex offender's property after the sex offender arrives. Sales price is increasing with distance until about 0.1 miles and then flattens out. The solid line is the relationship between sale price and distance from a sex offender's property before the sex offender arrives. Sales price is decreasing with distance until about 0.1 miles and then flattens out. Since the prices of homes are similar between 0.1 and 0.3 miles from an offender's location, properties within that distance are in the control group and properties within 0.1 mile of a sex offender's location are in the treatment group. Figure 2.3b shows the relationship between sales price and days relative to a sex offender's arrival. For properties in the treatment group, there is a significant decrease in property values after the sex offender's arrival. Properties within 0.1 and 0.3 miles of a sex offender's location remained relatively steady post arrival suggesting properties within that distance can indeed be considered "untreated."

Once the treatment and control groups have been defined, the following regression will be estimated:

$$\ln P_{ijt} = \pi_1 D^1_{ijt} + \pi_2 Post_{ijt} + \pi_3 D^1_{ijt} \cdot Post_{ijt} + x_{ijt}\delta_t + \lambda_t + \gamma_j + \epsilon_{ijt} \tag{2.4}$$

where D_{ijt}^{1} is a dummy variable equal to 1 if the property is located in close enough to an antenna site to be in the treatment group, $Post_{ijt}$ is a dummy variable equal to one if the property sold after the nearest antenna was constructed. π_3 is the parameter of interest. x_{ijt} contains an extensive set of housing characteristics, λ_t are year-month dummy variables, and γ_j are spatial fixed effects. Notice that this specification allows the equilibrium price function for the housing characteristics to vary over time. This is the specification shown to produce the smallest amount of bias in mean willingness to pay in Kuminoff et al. (2010). Since house prices in the study area appear to be relatively stable over time, a separate regression assumes $\delta_t = \delta$ for all t will be estimated.

2.5 Results

2.5.1 Cross-Section Results

Results for the first specification that uses a continuous measure of distance to the nearest antenna are shown in Table 2.6. The first two columns do not include any spatial fixed effects to control for time-invariant unobservables that may be correlated with proximity to an antenna. Without these spatial fixed effects, the estimates in Columns 1 and 2 suggest that houses located adjacent to a communication antenna sell for more than a comparable house further away from an antenna. This result is opposite of what is expected. Column 3 includes census tract fixed effects and the results show that holding constant the characteristics of the house, the time the property was sold, and the area of the property, consumers are willing to pay a premium to be located further away from a communication antenna[16]. Unobservables that are correlated with distance to a communication antenna are likely biasing the estimates in Columns 1 and 2. The estimates in Column 3 show that the sales price of a house is increasing at a rate of

[16]The results in Table A1.2 show that when census tract fixed effects are included, the coefficients on the structural housing and neighborhood characteristics change indicating they are also correlated with unobservables at the census tract level.

approximately 0.98% at a distance of 1,000 feet, and at a rate of about 0.88% at 2,500 feet[17]. No effect is found beyond 16,050 feet (approximately 3 miles). Column 4 includes census block-group fixed effects which are more precise rather than the census tract fixed effects used in Column 3. These estimates suggest that the sales price of a house increases at a rate of about 0.83% at a distance of 1,000 feet, and a rate of 0.75% at 2,500 feet. No effect is found beyond 15,540 feet (approximately 2.9 miles). Even though the effect of distance is identified by variation in distance within a smaller geographic area, the specification using census block group fixed effects provides estimates that are smaller and more precisely estimated than the census block specification. This provides further evidence that there are spatially correlated unobservables that are negatively correlated with distance to a communication antenna[18].

The results from the specification that uses the inverse of distance to the nearest antenna are shown in Table 2.7. As in Table 2.6, the first two columns do not include spatial fixed effects and the coefficients on the inverse of distance indicate that houses near antennas sell for more than houses further away. Once again, Column 3 shows that the census tract fixed effects are absorbing the effect of time invariant unobservables that are correlated with distance to an antenna, and the coefficient on the inverse of distance now has the expected sign. These estimates show that the sales price of a house is increasing at a rate of approximately 3.6% at a distance of 1,000, feet, and at a rate of about 0.57% at 2,500 feet[19]. When census block-group fixed effects are included (Column 4), the estimates show that the sales price of a house is increasing at a rate of about 2.8% at a distance of

[17]Using the quadratic of distance, the change in expected sales price with respect to distance is $\hat{\beta}_1 + 2 \cdot \hat{\beta}_2 \cdot D$, where D is distance to the nearest antenna in thousands of feet.

[18]Regressions were estimated that included the percentage of rural residents in a census tract instead of census tract fixed effects. The results show that the sales price of a house is decreasing as the number of people living in rural areas increases, and that proximity to a communication antenna has a positive effect on the sales price of a house in highly urban areas, and a negative effect in more rural areas. This is consistent with the idea that antennas in more urban areas are more likely to be disguised than in rural areas where the antennas structures tend to be much larger. Urban areas have multiple structures such as tall buildings, smoke stacks, clocks, and church steeples that antennas can be located on or around. The R^2 for the urban/rural specification was 0.72 compared to 0.85 in the census tract specification in Table 2.6.

[19]Using the inverse of distance, the change in expected sales price with respect to distance is $-\hat{\beta}/D^2$.

1,000 feet, and a rate of 0.45% at 2,500 feet. Since the derivative with respect to distance is never zero for the inverse of distance, the distance at which sales prices are increasing at a rate of 0.01% was found using the estimates from Column 4 in Tables 2.6 and 2.7. This distance is equal to 15,366 feet (2.9 miles) for the quadratic specification and 16,850 feet (3.2 miles) for the inverse of distance.

Overall, the results do not appear to be extremely sensitive to functional form when using a continuous measure of distance, but there are some differences. The inverse distance shows the effect declining more with distance and a greater effect for houses closer to an antenna. When using the inverse of distance, the partial derivative of the hedonic price function with respect to distance is $0.0284/\text{Distance}^2$ in the census block group specification. In the limit, this is equal to infinity as distance goes to zero, and equals zero as distance goes to infinity. At the median value of 4,500 feet, the inverse distance specification shows that the sales price of a house is increasing at a rate of 0.14% and at a rate of 0.6% using the quadratic specification. The distances at which the sales prices are increasing at the same rate for the two specifications are 1,905 and 15,330 feet. It is reassuring that the latter distance is only 210 feet short of the distance at which no sales price effect is found using the quadratic specification.

The results in Table 2.8 estimate the same quadratic specification that was used in Table 2.6, but the sample is restricted to only include the tower-type antenna structures. These structures are larger and are visible at greater distances than the smaller antenna structures and are expected to have a larger effect on property values and have an effect at greater distances. Columns 1 and 2 do not include spatial fixed effects and again indicate that houses in close proximity to an antenna sell for more than a comparable house further away. Once census tract fixed effects are included (Column 3), the estimates have the expected sign and indicate that the tower-type structures do in fact have a larger effect on property values and have an effect further away. Sales prices are increasing at a rate of

1.1% (up from 0.98%) at 1,000 feet, and a rate of 1.1% (up from 0.88%) at 2,500 feet. No effect is found beyond 16,667 feet (3.16 miles). Column 4 includes census block-group fixed effects and once again the effect of distance to a tower on property values is estimated more precisely than in the census tract specification. With this specification, sales prices are increasing at a rate of 1% (up from 0.83%) at 1,000 feet and 0.92% (up from 0.75%) at 2,500 feet. No effect is found beyond 16,269 feet (3.08 miles). While the effects are not extremely different, the estimates are larger when the sample is reduced to only tower-type structures. This provides additional confidence that the proximity measures being used are capturing the visual disamenity associated with communication antennas[20].

The estimates in Tables 2.9 and 2.10 use 300 foot distance bands to measure either the effect of having an antenna located within a specified radius from the house (Table 2.9) or the marginal effect of an additional tower within the same radius (Table 2.10). The summary statistics in Table 2.3 show that there are only 127 houses whose nearest antennas is less than 300 feet away so the 0 to 300 foot and 300 to 600 foot distance bands were combined to ensure there is enough variation to identify the effect of distance for houses located closest to an antenna. The estimates in Columns 1 and 2 in Tables 2.9 and 2.10 do not include spatial fixed effects and indicate houses near antennas sell for more than houses further away. Row 1 of Columns 1 and 2 suggest that houses within 600 feet of an antenna sell for 13-14% more than a house more than 4,500 feet from an antenna (Table 2.9) and that an additional antenna within 600 feet leads to an additional 9 to 10% increase in sales price (Table 2.10). Again, when census tract fixed effects are included, the estimates have the expected sign and suggest that a house located within 600 feet of an antenna sell for 6.3% less than a comparable house more than 4,500 feet from the nearest antenna, and an additional antenna leads to a 3.8% reduction in sales price. When census

[20]Each specification discussed below is also estimated using only tower-type antenna structures. To save space, the results for these specifications are given in the appendix. In general, the estimates using only the tower-type antenna structures show a larger effect and have an effect at greater distances.

block-group fixed effects are included, the effect of having an antenna within 600 feet of a property falls to a 5.7% reduction in sales price with an additional antenna leading to a 3.1% reduction. In both specifications, the effect of communication antennas on property values diminishes with distance[21].

The results in Tables 2.9 and 2.10 are consistent with the argument made in Mastromonaco (2011) that only considering distance to the nearest site will lead to biased estimates if there are multiple sites that could adversely affect a property's sale price. As is expected, adding an additional antenna near a residential property has a smaller effect than an antenna being located near a property that did not previously have one nearby. Since every coefficient in Columns 3 and 4 of Table 2.9 is larger than the corresponding coefficient in Columns 3 and 4 of Table 2.10, the estimates that measure proximity with distance to the nearest site are likely biased. To address this concern, the results in Table 2.11 use the same quadradic measure of distance to the nearest antenna that was used Table 2.6 but include the number of antennas near a property using the 300 foot distance bands from Table 2.10. As expected, the results suggest that only considering proximity to the nearest antenna is biased if there are multiple antennas that could be affecting the property's sale price. The results from Column 4 of in Table 2.11 show that holding constant the number of nearby antennas, the sales price of a house is increasing at a rate of 0.34% at a distance of 1,000 feet from an antenna, and at a rate of 0.30% at 2,500 feet

[21] Bond and Wang (2005) and Bond (2007a) are two similar studies that measure the impact of cell phone towers on property values in New Zealand, but the studies have limitations. The first lacked precise location information for the houses and used street name fixed effects as a proxy for distance to a tower. The second geocodes houses, but the model is misspecified. They use a continuous distance measure but set distance equal to zero if the house sold before the tower was constructed. Bond (2007b) is the only study found that uses U.S. data. It is limited to sales from one area of Orange County Florida and includes the latitude and longitude of each property in each regression. Banfi et al. (2008) looks at the impact of cell phone towers on rents in Zurich Switzerland and finds a significant decrease in rents of about 1.5% on average. Filippova and Rehm (2011) is the most recent study. They use data from the Auckland region of New Zealand and also use distance bands and a continuous distance measure. Their distance band specification yields insignificant results, and the coefficient on the continuous distance measure has a significant, but wronged signed coefficient. They report a negative but insignificant impact on property values. The authors failed to consider the interaction terms between distance and their location variables. Given they used 50 meter increments for their distance bands, it is likely there was not enough variation within each band to identify any impact.

from an antenna. These estimates are significantly smaller than those in Table 2.6 that only considered distance to the nearest antenna.

2.5.2 Panel Results

Results from the first repeat sales specification that assumes the structural housing characteristics are constant over time are shown in Table 2.12. In this specification, the change in sales price is assumed to be a function of the change in distance to the nearest antenna and a set of year dummy variables that are equal to -1 if the year indicates the time of the first sale, 1 if the year indicates the year of the last sale, and 0 for all other sales. Comparing the change in sales price for houses that are sold more than once eliminates any bias that could be caused by time-invariant spatially correlated unobservables. Comparing Columns 3 and 4 for each cross-section specification shows that as more precise spatial fixed effects are used, the estimated effect of communication antennas on the sales price of a house is smaller and more precisely estimated. This indicates that the spatially correlated unobservables are negatively correlated with proximity to an antenna. If this is true, and the unobservables are time invariant, the repeat sales estimates of the impact communication antennas have on property values should be similar to the estimates using the more precise census block group fixed effects.

The results in each Column of Table 2.12 are consistent with this hypothesis. Column 1 includes all houses that sold more than once during the sample period. For every 1,000 foot change in distance to the nearest antenna, on average, the sales price if a house increases by 0.75%. This estimate is similar the rate at which sales prices are increasing in Table 2.6 at a distance of 1,000 feet (0.83%). Columns 2 and 3 included houses that are sold four or fewer times and three or fewer times, respectively. Both provide estimates similar to Column 1 where all repeat sales are included. Column 4 includes the set of houses that are sold only twice during the 12 years the data cover. Since repeat sales are

identified by the standardized address provided by the Mapquest scraping program, limiting the sample to houses that sale only two times reduces the chance of including houses that are being considered repeat sales due to a coding error. Even though the sample size is reduced by 8,910 observations compared to the sample of all repeat sales, the R^2 increases by 3.2 points, and the effect of distance is still precisely estimated. In this specification, for every 1,000 foot change in distance to the nearest antenna, on average, the sales price if a house increases by 0.33%. This is slightly smaller than the estimate in Column 4 of Table 2.11 that holds the number of antennas near a house constant when estimating the effect of proximity of an antenna, but much smaller than the estimates in Column 4 of Tables 2.9 and 2.10 that used the 300 foot distance bands.

The repeat sales results in Table 2.13 relax the assumption that structural housing characteristics are constant over time. As is expected, including the changes in structural housing characteristics lead to a higher R^2, increases in each characteristic lead to a larger positive change in sales price, and the effect of distance is more precisely estimated. This suggests that the change in distance to the nearest antenna between sales of the same property is not orthogonal to the change in housing characteristics, an assumption that must be made when detailed sales data is not used. Again, Columns 1 through 3 include all repeat sales, houses that sell four or fewer times, or houses that sell three or fewer times. These results show a slightly larger effect than the results shown in Table 2.12. When the sample is reduced to houses that only sell twice during the sample period, the estimated impact is slightly larger than the estimate in Table 2.12. In this specification, for every 1,000 foot change in distance to the nearest antenna, on average, the sales price of a house increase by 0.38% compared to 0.33% when the structural characteristics are assumed to be constant. While these estimates are not statistically different at conventional levels[22], a larger effect when the changing structural housing characteristics are included is consistent with the results from Bajari et al. (2012) that show ignoring time-varying

[22]P-value from a Chow test=.12.

correlated unobservables leads to underestimates of the benefits of pollution reduction.

The method used for determining the treatment and control groups for the difference-in-differences specification is shown in Figure 2.4. The solid line shows the relationship between the sales price of a house and distance to the nearest antenna that was standing at the time it was sold. Sales prices are increasing until about 2,000 feet and then flatten out. The dashed line shows the relationship between the sales price of a house and distance to the nearest site where an antenna will be located. Sales prices are decreasing with distance from the site where an antenna will be located and flatten out at about 2,000 feet. Since 2,000 feet is the point at which the sales price is not affected by an antenna that is standing, or the site where an antenna will be located, houses within 2,000 feet of an antenna site are considered “treated" and those beyond are in the control group.

Estimates from the difference-in-differences specification are shown in Table 2.14. Column 1 says that holding constant the structural characteristics and the time of sale, houses within 2,000 feet of where an antenna is located or will be located sell for 2.9% more on average than a comparable house more than 2,000 feet of an antenna site. Holding constant the areas in which houses are located, Column 2 shows that a house within 2,000 feet of an antenna site sells for about 1% less than a comparable house more than 2,000 feet away. This result is consistent with all of the results above and reinforces the importance of including the spatial fixed effects to capture the effect of spatially correlated unobservables. Column 3 reports results from a typical difference-in-difference specification. Houses that are within 2,000 feet of an antenna at the time they were sold sell for about 3.3% less than a comparable house more than 2,000 feet away from an antenna at the time it was sold. The results in Column 4 are from a specification that allows the equilibrium price function with respect to structural housing characteristics change over time and also includes spatial fixed effects. Kuminoff et al. (2010) recommend this specification for estimating willingness to pay when using panel data.

The results from this specification show an effect of about 2.2% that is estimated more precisely than in the specification that does not allow the equilibrium price function to change over time, however, the effect is not significantly different from zero at conventional levels.

2.6 Discussion and Conclusions

The results above show that houses located near communication antennas sell for less on average than comparable houses located further away from an antenna. There are a few important points to note about these results. First, regardless of the specification, time-invariant spatially correlated unobservables biased the cross-sectional estimates of the reduction in sales price caused by nearby communication antennas. Columns 1 and 2 in Tables 2.6-2.11 do not include any spatial fixed effects and all show that houses near a communication antenna sells for more than a similar house further away from an antenna. Following the recommendation from Kuminoff et al. (2010), Columns 3 and 4 of Tables 2.6-2.11 include spatial fixed effects to capture the effect of time invariant spatially correlated unobservables. Once included, each proximity measure that was used indicates that houses near communication antennas sell for less than a similar house located further away from an antenna. When the more precise census block group fixed effects are included, the estimated reduction in sales price caused by a communication antenna becomes smaller and is estimated more precisely in each of the cross-section specifications. This reinforces the importance of the carefully controlling for spatial correlated unobservables that are correlated with proximity to a localized disamentiy.

The results also show that when using a continuous measure of distance, the results are robust to functional form. When the quadratic specification is used, the sales price of a house is increasing at a rate of 0.75% at a distance of 2,500 feet from an antenna, and at a rate of 0.57% at 2,500 feet using the inverse of distance. At an average sales price of

$183,619, this amounts to a difference of $275. Even though the differences are small, the results from the continuous specifications also provide evidence that the proximity measures are capturing the visual disamenity associated with communication antennas. Comparing the results in Column 4 of Table 2.6 to the results in Column 4 in Table 2.8, the bigger tower-type structures have a larger effect on the sales price of a house and have an effect further away. Using all antennas, the sales price of a house is increasing at a rate of 0.75% at 2,500 feet from an antenna, and the sales price of a house is increasing at a rate of 0.92% at the same distance from a tower-type antenna, a difference of $312.

Consistent with the conjecture made by Mastromonaco (2011), estimating the effect of communication antennas on property values using distance to the nearest antenna is likely biased due to the presence of multiple nearby antennas. The results in Column 4 of Table 2.9 say that a house located within 600 feet of an antenna sells for 5.7% ($10,466) less than a similar house more than 4,500 feet away from its nearest antenna. The results in Column 4 of Table 2.10 show that adding an additional antenna within 600 feet of a house leads to a reduction in sales price of 3.1% ($5,692). Since houses are being affected by multiple nearby antennas, Table 2.11 uses the same quadratic specification from Table 2.6 but includes the number of antennas located near each house using the same distance bands that were used in Table 2.10. Holding constant the number of communication antennas near a property, the sales price increasing at a rate of 0.34% at a distance of 1,000 feet compared to a rate of 0.83% at 1,000 feet when only the nearest antenna is considered. Using the average sales price of $183, 619, this is a difference of $881.

The results suggest that the omitted spatial characteristics that are correlated with proximity to a communication are time invariant and are being captured by the census block group fixed effects. First, the effect communication antennas have on nearby properties is smaller and is estimated more precisely when census block group fixed effects are used compared to the census tract estimates. This confirms that there are

unobservables that are spatially correlated with distance to a communication antenna. Second, the repeat sales method eliminates any bias caused by time-invariant unobservables and provides results very similar to the cross sectional estimates that include census block group fixed effects. This can be seen by comparing the results in Column 4 of Table 2.11 to the results in Column 4 of Table 2.13. Using the continuous measure of distance, Table 2.11 shows that the sales price of a house is increasing at a rate of 0.34% at a distance of 1,000 feet from an antenna, and Table 2.13 show that for every 1,000 foot change in distance to the nearest antenna, the sales price increases by 0.39%. Using the average sales price of $183,619, this amounts to a difference of $92.

Kuminoff et al. (2010) recommend using difference-in-differences to estimate marginal willingness to pay for localized (dis)amenities when panel data is available. They suggest including spatial fixed effects to capture the effect of time-invariant spatially correlated unobservables, and interacting time dummy variables with the housing characteristics to allow the equilibrium price function to vary over time. Table 2.14 shows the results from this specification. The estimates in Column 3 are from the typical difference-in-difference specification that assumes the equilibrium price function is constant over time and show that houses within 2,000 feet of a standing antenna sell for 3.3% ($6,059) less than a similar house more than 2,000 feet away from antenna. In the more flexible specification that allows the equilibrium price function to change over time, the 2.2% ($4,040) effect is estimated more precisely, but is not statistically different from zero at conventional levels.

It is not surprising that the difference-in-differences specification does not produce results similar to the repeat sales estimates or the cross-section estimates that include census block group fixed effects. The primary reason is that the presence of multiple antennas near a property makes defining the treatment and control groups difficult. To define the treatment and control groups, the distance from each house to a site where an antenna is standing or will be standing is determined. This distance may identify distance to a site

where an antenna will be located, but will ignore the already standing antenna that is just beyond that site. The summary statistics in Table 2.3 show that this is a valid concern. There are 804 houses that are located within 2,100 feet of at least two antennas when they sold. Since the distance to a site where an antenna will be located will be highly correlated with distance to the nearest standing antenna for a lot of the houses in the sample, identifying the treatment and control groups using the method from Linden and Rockoff (2008) is not likely to be effective. While the difference-in-differences specification has become increasing popular in the recent literature, the nature of the disamenity evaluated here does not appear meet the criteria necessary to successfully implement this quasi-experimental technique.

The best estimate of reduction in sales price cause by communication antennas shows that the sales price of a house is increasing at a rate of about 0.34% ($624) at a distance of 1,000 feet from the nearest antenna (Table 2.11 Column 4). This relationship is shown graphically in Figures 2.5 and 2.6. This suggests that a house within 1,000 feet of the nearest antenna when it is sold will sell for 1% ($1,836) less than a similar house that is 4,500 feet from the nearest antenna. The results in Column 2 of Table 2.11 do not include any spatial fixed effects and show that the sales price of a house is decreasing at a rate of 0.4% at a distance of 1,000 feet. This suggests that is within 1,000 feet of the nearest antenna will sell for 1.1% ($2,020) more than a similar houses that is 4,500 feet from the nearest antenna. This reinforces how important it is to include precise spatial fixed effects to capture the effect of time invariant spatially correlated unobservables.

This effect is smaller than the estimated reduction caused by similar disamenities. Kroll and Priestley (1992) provide a review of the literature concerning overhead transmission lines and property values through the early 1990s. They find that in studies where a significant decrease was found, the decrease in property values typically falls in the range of 2% to 10%, and the effect diminishes beyond a few hundred feet. Hamilton and

Schwann (1995) estimate the impact of high voltage electric transmission lines have on property values, but primarily focus on the importance of using the correct functional form. They find that properties that are adjacent to a line lose about 6.3% of their value, but more distant properties are hardly affected. Using a repeat sales model, Heintzelman and Tuttle (2012) find that having a wind turbine located 0.5 miles away leads to a reduction in sales price from 8.8-15.81%.

Figure 2.1a illustrates the potential externality caused by these antennas. If antennas are constructed near residential properties *after* the homeowner purchases the property, they suffer a small but non-trivial decrease in their property value and are unlikely to be compensated by the land owner where the antenna is located or the antenna's owner. "Camouflaging" is one solution to this problem that has been implemented in some areas. Camouflaged towers blend in with the landscape or are constructed in already standing structures such as church steeples and clock towers. A stated preference study of the disamenity associated with communication antennas would allow various types of camouflaging to be valued in different locations. Such developments will change the disamenity associated with communication antennas.

2.7 Tables and Figures

Table 2.1: Summary Statistics for Structural Housing Characteristics. Central Kentucky Data, 2000-2011. N=142,164.

Variable	Mean/Share	Std. Dev.	Min	Max
Sales Price (2011 Dollars)[a]	183,619	143,162	1,028	4,859,483
Bedrooms	3.241	0.785	1	13
Full Bathrooms	1.811	0.751	1	9
Partial Bathrooms	0.368	0.522	0	6
Square Feet of Living Space	1,655	7,181	500	9,688
Lotsize (Acres)	0.820	40.661	0	436
Lotsize Missing	0.047	0.211	0	1
Has $<$ in Lot Dimensions[b]	0.127	0.333	0	1
Has $>$ in Lot Dimensions[b]	0.003	0.058	0	1
Age (Years)	33.154	29.074	0	223
Age Unknown	0.010	0.101	0	1
Fireplace	0.479	0.500	0	1
Basement	0.602	0.490	0	1
Finished Basement	0.175	0.380	0	1
Central Air	0.909	0.287	0	1
Brick Exterior	0.346	0.476	0	1
Vinyl Exterior	0.162	0.369	0	1
Metal Roof	0.010	0.099	0	1
Composition Roof	0.940	0.238	0	1
Ranch Style	0.447	0.497	0	1
Modular Style	0.014	0.116	0	1
Cape Cod Style	0.084	0.277	0	1
Carport	0.057	0.233	0	1
Garage	0.663	0.473	0	1
One Car Garage	0.169	0.374	0	1
Multiple Car Garage	0.563	0.496	0	1
Within 1 Mile Parkway/Interstate	0.485	0.500	0	1
Within 1 Mile Railroad	0.511	0.500	0	1
Within 1 Mile Ft. Knox	0.014	0.116	0	1

[a] Sales prices were converted to 2011 dollars using the CPI.
[b] The lot dimensions indicated the lot size was less (greater) than the listed size.

Table 2.2: Averages and Test for Differences in Means for Houses Within and Beyond 4,500 Feet of an Antenna. Central Kentucky Data, 2000-2011.

	Mean/Share		
Variable	<4,500 Feet	>4,500 Feet	Test Statistic
Sales Price (2011 Dollars)	167,247	200,226	43.61
Bedrooms	3.161	3.323	39.00
Full Bathrooms	1.687	1.937	63.66
Partial Bathrooms	0.347	0.390	15.83
Square Feet of Living Space	1,573	1,739	43.70
Lotsize (Acres)	0.383	1.263	35.52
Lotsize Missing	0.044	0.049	3.96
Has < in Lot Dimensions	0.149	0.105	-24.96
Has > in Lot Dimensions	0.003	0.004	2.81
Age (Years)	42.078	24.096	-122.86
Age Unknown	0.006	0.014	14.65
Fireplace	0.474	0.485	4.09
Basement	0.613	0.590	-8.96
Finished Basement	0.153	0.197	21.80
Central Air	0.898	0.921	15.050
Brick Exterior	0.322	0.370	18.89
Vinyl Exterior	0.157	0.168	5.69
Metal Roof	0.006	0.013	13.16
Composition Roof	0.944	0.936	-6.90
Ranch Style	0.409	0.485	29.19
Modular Style	0.004	0.024	31.68
Cape Cod Style	0.102	0.066	-24.23
Carport	0.066	0.049	-13.44
Garage	0.657	0.668	4.34
One Car Garage	0.209	0.128	-41.29
Multiple Car Garage	0.494	0.632	53.00
Within 1 Mile Parkway/Interstate	0.629	0.338	-114.93
Within 1 Mile Railroad	0.569	0.452	-44.19
Within 1 Mile Ft. Knox	0.014	0.014	-0.560
Sample Size	71,604	70,560	

[a] Sales prices were converted to 2011 dollars using the CPI.
[b] The lot dimensions indicated the lot size was less (greater) than the listed size.

Table 2.3: Summary Statistics for the Communication Antenna Proximity Measures. Central Kentucky Data, 2000-2011. N=142,164.

Continuous	Mean	Std. Dev.	Min	Max
Distance to Closest Standing Antenna When Sold (feet)[a]	5,794	4,703	59	51,663

Equal to 1 if Within	Share	Number
Distance0to300	0.001	127
Distance300to600	0.005	752
Distance600to900	0.010	1,467
Distance900to1200	0.017	2,458
Distance1200to1500	0.026	3,641
Distance1500to1800	0.031	4,350
Distance1800to2100	0.034	4,831
Distance2100to2400	0.041	5,832
Distance2400to2700	0.044	6,262
Distance2700to3000	0.049	6,959
Distance3000to3300	0.050	7,128
Distance3300to3600	0.050	7,055
Distance3600to3900	0.051	7,193
Distance3900to4200	0.049	7,018
Distance4200to4500	0.046	6,531

Number Within	# Equal to 1	# Equal to 2	# Equal to 3
Count0to300	122	5	0
Count300to600	733	23	0
Count600to900	1,471	54	0
Count900to1200	2,473	80	0
Count1200to1500	3,744	148	3
Count1500to1800	4,620	204	9
Count1800to2100	5,538	290	2
Count2100to2400	6,829	365	12
Count2400to2700	7,764	475	22
Count2700to3000	8,965	690	10
Count3000to3300	10,031	757	48
Count3300to3600	10,580	848	62
Count3600to3900	11,595	1043	109
Count3900to4200	12,898	1268	128
Count4200to4500	13,511	1364	128

[a] Distance in thousands of feet is used in the analysis that follows.

Table 2.4: Changes in Census Tract Demographics from 2000 to 2010. 322 Census Tracts in Central Kentucky.

	U.S. Mean			Sample Mean		
Variable	2000	2010	% Change	2000	2010	% Change
Mean Income[a]	71,728	70,883	-1.18	63,924	60,290	-6.00
Median Income[a]	53,176	51,914	-2.37	51,805	48,649	-6.00
% Unemployed	3.70	7.90	113.51	5.24	8.49	62.00
% No High School Diploma	12.10	8.70	-28.10	13.91	10.41	-25.00
% High School Diploma	28.60	29.00	1.40	34.43	35.36	3.00
% Bachelors Degree or Higher	24.40	27.90	14.34	17.38	20.46	18.00
% Black	12.00	12.00	0.00	9.01	9.62	7.00
% White	75.00	74.00	-1.33	88.21	86.66	-2.00
% Owns Home	66.00	67.00	1.52	72.73	71.05	-2.00
% Out of State	8.40	2.40	-71.00	8.13	9.12	12.00

[a] Incomes were converted to 2010 dollars using the CPI.

Table 2.5: Summary Statistics for Changing House Characteristics for Houses that Sold More Than Once. Central Kentucky Data, 2000-2011. 26,579 Unique Repeat Sales.

Variable	Number Changed	Percent Changed
Number of Bedrooms	4,311	17
Number of Full Bathrooms	2,617	10
Number of Partial Bathrooms	1,486	6
Finished Basement	4,558	18
Central Air	2,783	11
Has Garage	3,097	12
Has Carport	666	3

Table 2.6: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values using a Continuous Measure of Distance. Central Kentucky Data, 2000-2011.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance to Any Antenna	-0.00922***	-0.0113***	0.0104***	0.00892***
	(0.000624)[b]	(0.000610)	(0.00195)	(0.00176)
Distance^2 to Any Antenna	0.000162***	0.000182***	-0.000324***	-0.000287***
	(2.34e-05)	(2.28e-05)	(6.18e-05)	(5.81e-05)
Constant	10.37***	10.38***	10.50***	10.23***
	(0.0104)	(0.0204)	(0.0315)	(0.0200)
Observations	142,161	142,161	142,161	142,161
R-squared	0.703	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.7: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values using the Inverse of Distance to the Nearest Antenna. Central Kentucky Data, 2000-2011.

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Inverse Distance to Any Antenna	0.0805***	0.0902***	-0.0358***	-0.0284***
	(0.00372)	(0.00364)	(0.00887)	(0.00755)
Constant	10.29***	10.28***	10.56***	10.28***
	(0.00994)	(0.0202)	(0.0302)	(0.0187)
Observations	142,161	142,161	142,161	142,161
R-squared	0.703	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.8: Cross-Section Regression Results Showing the Effect of Towers Only on Property Values using a Continuous Measure of Distance. Central Kentucky Data, 2000-2011.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance to Tower	-0.00446***	-0.00737***	0.0119***	0.0109***
	(0.000597)[b]	(0.000585)	(0.00213)	(0.00187)
Distance^2 to Tower	2.23e-05	6.31e-05***	-0.000357***	-0.000335***
	(2.24e-05)	(2.19e-05)	(6.54e-05)	(6.04e-05)
Constant	10.34***	10.36***	10.49***	10.22***
	(0.0104)	(0.0204)	(0.0315)	(0.0205)
Observations	142,161	142,161	142,161	142,161
R-squared	0.702	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.9: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values Using the Nearest Antenna Method with the Closest Rings Combined. Central Kentucky Sales Data. 2000-2011.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance0to600	0.131***	0.140***	-0.0630***	-0.0572***
	(0.0136)[b]	(0.0133)	(0.0196)	(0.0178)
Distance600to900	0.0982***	0.111***	-0.0756***	-0.0699***
	(0.0106)	(0.0104)	(0.0168)	(0.0152)
Distance900to1200	0.105***	0.121***	-0.0697***	-0.0727***
	(0.00829)	(0.00809)	(0.0160)	(0.0141)
Distance1200to1500	0.110***	0.122***	-0.0509***	-0.0581***
	(0.00689)	(0.00672)	(0.0119)	(0.0107)
Distance1500to1800	0.0798***	0.0911***	-0.0600***	-0.0687***
	(0.00634)	(0.00619)	(0.0114)	(0.0106)
Distance1800to2100	0.0623***	0.0736***	-0.0516***	-0.0544***
	(0.00603)	(0.00589)	(0.0113)	(0.0102)
Distance2100to2400	0.0425***	0.0565***	-0.0511***	-0.0536***
	(0.00554)	(0.00541)	(0.0114)	(0.00964)
Distance2400to2700	0.0413***	0.0547***	-0.0476***	-0.0448***
	(0.00535)	(0.00523)	(0.0106)	(0.00862)
Distance2700to3000	0.0115**	0.0239***	-0.0512***	-0.0457***
	(0.00510)	(0.00499)	(0.0108)	(0.00849)
Distance3000to3300	0.00454	0.0164***	-0.0525***	-0.0489***
	(0.00504)	(0.00492)	(0.00990)	(0.00825)
Distance3300to3600	0.0232***	0.0337***	-0.0406***	-0.0360***
	(0.00507)	(0.00495)	(0.00940)	(0.00778)
Distance3600to3900	0.0130***	0.0230***	-0.0419***	-0.0356***
	(0.00501)	(0.00489)	(0.00918)	(0.00712)
Distance3900to4200	0.0239***	0.0327***	-0.0275***	-0.0201***
	(0.00505)	(0.00493)	(0.00837)	(0.00660)
Distance4200to4500	0.0210***	0.0270***	-0.0168**	-0.00857
	(0.00521)	(0.00509)	(0.00707)	(0.00627)
Constant	10.29***	10.28***	10.56***	10.30***
	(0.00993)	(0.0201)	(0.0295)	(0.0194)
Observations	142,164	142,164	142,164	142,164
R-squared	0.703	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.10: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values Using the Antenna Count Method with the Closest Rings Combined. Central Kentucky Sales Data. 2000-2011.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Count0to600	0.0993***	0.100***	-0.0384**	-0.0307**
	(0.0129)[b]	(0.0126)	(0.0166)	(0.0148)
Count600to900	0.0636***	0.0693***	-0.0502***	-0.0458***
	(0.00981)	(0.00957)	(0.0146)	(0.0133)
Count900to1200	0.0697***	0.0784***	-0.0432***	-0.0483***
	(0.00766)	(0.00748)	(0.0131)	(0.0118)
Count1200to1500	0.0732***	0.0787***	-0.0307***	-0.0371***
	(0.00617)	(0.00602)	(0.00973)	(0.00900)
Count1500to1800	0.0493***	0.0536***	-0.0397***	-0.0480***
	(0.00551)	(0.00538)	(0.00810)	(0.00769)
Count1800to2100	0.0453***	0.0494***	-0.0291***	-0.0315***
	(0.00502)	(0.00490)	(0.00795)	(0.00719)
Count2100to2400	0.0299***	0.0363***	-0.0264***	-0.0303***
	(0.00451)	(0.00440)	(0.00870)	(0.00702)
Count2400to2700	0.0305***	0.0362***	-0.0289***	-0.0277***
	(0.00418)	(0.00408)	(0.00706)	(0.00635)
Count2700to3000	0.00339	0.00958**	-0.0307***	-0.0286***
	(0.00385)	(0.00376)	(0.00739)	(0.00608)
Count3000to3300	0.00398	0.00951***	-0.0299***	-0.0311***
	(0.00362)	(0.00353)	(0.00694)	(0.00557)
Count3300to3600	0.0167***	0.0213***	-0.0251***	-0.0239***
	(0.00349)	(0.00340)	(0.00608)	(0.00482)
Count3600to3900	0.00973***	0.0147***	-0.0291***	-0.0274***
	(0.00323)	(0.00315)	(0.00626)	(0.00504)
Count3900to4200	0.0255***	0.0304***	-0.0237***	-0.0196***
	(0.00306)	(0.00299)	(0.00652)	(0.00465)
Count4200to4500	0.0215***	0.0266***	-0.0191***	-0.0140***
	(0.00302)	(0.00295)	(0.00613)	(0.00458)
Constant	10.29***	10.29***	10.56***	10.31***
	(0.00992)	(0.0201)	(0.0294)	(0.0206)
Observations	142,164	142,164	142,164	142,164
R-squared	0.703	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.11: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values using a Continuous Measure of Distance with the Density of Nearby Antennas. Central Kentucky Data, 2000-2011.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance to Any Antenna	-0.00166**	-0.00306***	0.00587***	0.00370*[d]
	(0.000785)[b]	(0.000766)	(0.00210)	(0.00193)
Distance^2 to Any Antenna	-6.54e-05**	-6.39e-05**	-0.000202***	-0.000145**
	(2.73e-05)	(2.66e-05)	(6.18e-05)	(5.93e-05)
Constant	10.32***	10.33***	10.53***	10.29***
	(0.0108)	(0.0206)	(0.0332)	(0.0222)
Observations	142,161	142,161	142,161	142,161
R-squared	0.704	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes
Density of Antennas[c]	Yes	Yes	Yes	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

[c] Density is measured as the the number of antennas located within specified distances from the property as in Table 2.10.

[d] The P-value (0.0001) from a Chow test confirms that the estimates in columns 3 and 4 for distance and distance squared are statistically different.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.12: Repeat Sales Regression Results Showing the Effect of All Antennas on Property Values Using a Continuous Measure of Distance. Constant Structural Characteristics. Central Kentucky Data, 2000-2011.

	(1)	(2)	(3)	(4)
VARIABLES[a]	Δ ln(Sold Price)	Δ ln(Sold Price)	Δ ln(Sold Price)	Δ ln(Sold Price)
Δ Distance to any Antenna	0.00754***	0.00748***	0.00727***	0.00332***
	(0.00103)[b]	(0.00103)	(0.00105)	(0.00111)
Constant	0.0545***	0.0553***	0.0610***	0.151***
	(0.00308)	(0.00311)	(0.00332)	(0.00525)
Observations	29,886	29,719	28,387	20,976
R-squared	0.102	0.103	0.107	0.144
All Repeats	Yes	No	No	No
Four or Less	No	Yes	No	No
Three or Less	No	No	Yes	No
Sold Only Twice	No	No	No	Yes

[a] Year dummy variables were also included. The dummy variables are equal to -1 if the year indicates the first sale of the property, 1 if the year indicates the year of the last sale of the property, and 0 otherwise.

[b] Standard errors are clustered at the property level.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.13: Repeat Sales Regression Results Showing the Effect of All Antennas on Property Values Using a Continuous Measure of Distance. Changing Structural Characteristics. Central Kentucky Data, 2000-2011.

VARIABLES[a]	(1) Δ ln(Sold Price)	(2) Δ ln(Sold Price)	(3) Δ ln(Sold Price)	(4) Δ ln(Sold Price)
Δ Distance to any Antenna	0.00746***	0.00739***	0.00722***	0.00388***
	(0.000965)[b]	(0.000968)	(0.000987)	(0.00104)
Δ Bedrooms	0.0785***	0.0770***	0.0740***	0.0619***
	(0.00558)	(0.00554)	(0.00557)	(0.00621)
Δ Full Bathrooms	0.170***	0.170***	0.170***	0.168***
	(0.00792)	(0.00795)	(0.00814)	(0.00897)
Δ Partial Bathrooms	0.104***	0.104***	0.106***	0.110***
	(0.00950)	(0.00951)	(0.00979)	(0.0113)
Δ Finished Basement	0.0210***	0.0213***	0.0210***	0.00960**
	(0.00383)	(0.00384)	(0.00393)	(0.00455)
Δ Central Air	0.255***	0.255***	0.251***	0.243***
	(0.00974)	(0.00979)	(0.0100)	(0.0116)
Δ Carport	0.0592***	0.0600***	0.0554***	0.0391***
	(0.0144)	(0.0146)	(0.0148)	(0.0150)
Δ Garage	0.0158**	0.0156**	0.0136*	0.0204**
	(0.00772)	(0.00775)	(0.00793)	(0.00899)
Constant	0.0354***	0.0361***	0.0411***	0.122***
	(0.00286)	(0.00289)	(0.00309)	(0.00489)
Observations	29,886	29,719	28,387	20,976
R-squared	0.202	0.202	0.203	0.230
All Repeats	Yes	No	No	No
Four or Less	No	Yes	No	No
Three or Less	No	No	Yes	No
Sold Only Twice	No	No	No	Yes

[a] Year dummy variables were also included. The dummy variables are equal to -1 if the year indicates the first sale of the property, 1 if the year indicates the year of the last sale of the property, and 0 otherwise.

[b] Standard errors are clustered at the property level.

*** p<0.01, ** p<0.05, * p<0.1

Table 2.14: Difference-in-Difference Estimates of the Effect of All Antennas on Property Values. Central Kentucky Data, 2000-2011.

VARIABLES[a]	(1) ln(Sold Price)	(2) ln(Sold Price)	(3) ln(Sold Price)	(4) ln(Sold Price)
Within 2000 Feet of an Antenna Site	0.0289***	-0.0101***	0.0135	0.00303
	(0.00294)[b]	(0.00250)	(0.0144)	(0.0133)
Antenna Standing When Sold			-0.0164**	-0.0206***
			(0.00801)	(0.00736)
Within 2000 Feet x Antenna Standing When Sold			-0.0334**	-0.0221
			(0.0152)	(0.0135)
Constant	10.29***	10.55***	10.56***	10.78***
	(0.0202)	(0.0905)	(0.0302)	(0.0324)
Observations	142,164	142,164	142,164	142,164
R-squared	0.716	0.853	0.853	0.861
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	No	Yes	Yes	Yes
Allows Effect of Housing Characteristics to Vary Over Time[c]	No	No	No	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

[c] Structural housing characteristics were interacted with time dummy variables.

*** p<0.01, ** p<0.05, * p<0.1

Figure 2.1a: Houses Likely Affected by Nearby Tower

Figure 2.1b: Houses Likely Unaffected by Nearby Tower

Figure 2.2: Four Quarter Percent Change in the FHFA Housing CPI

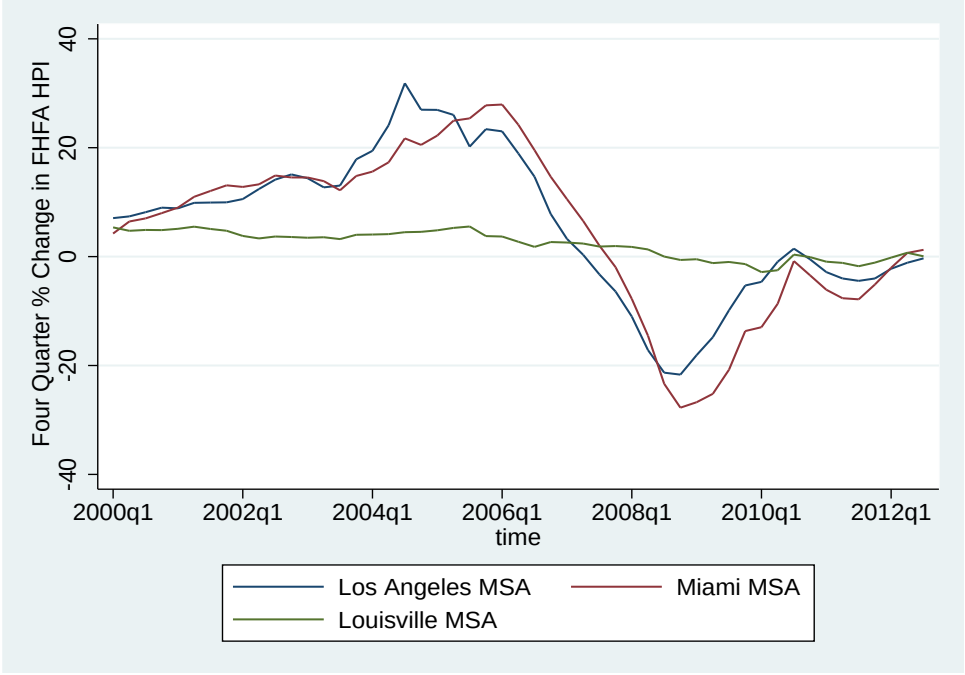


Figure 2.3a: Figure 2B in Linden and Rockoff (2008)

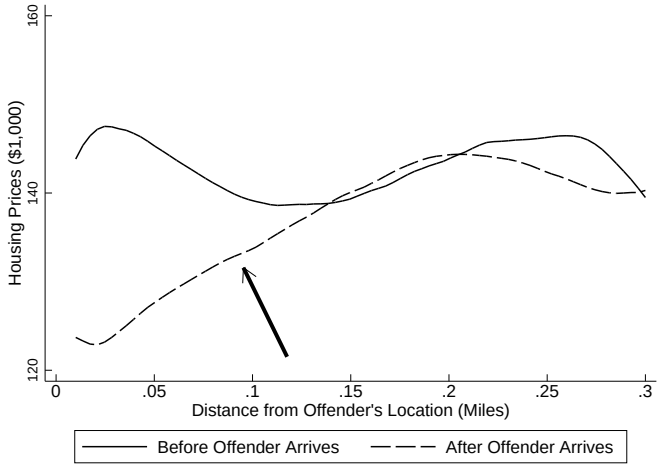


Figure 2.3b: Figure 3B in Linden and Rockoff (2008)

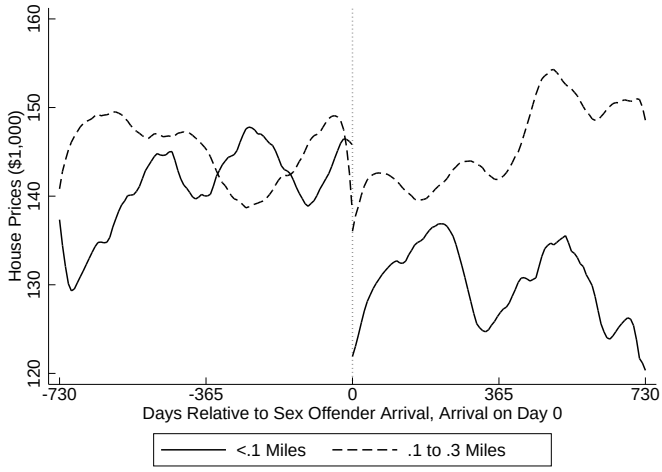


Figure 2.4: Non-Parametric Plot of the Relationship Between Sales Price and Distance to the Nearest Antenna

Figure 2.5: Partial Relationship Between Sales Price and Distance to the Nearest Antenna

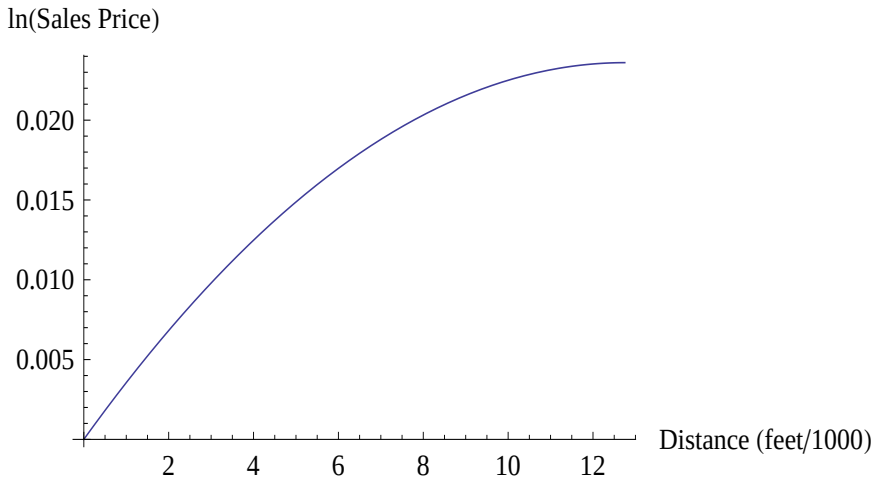
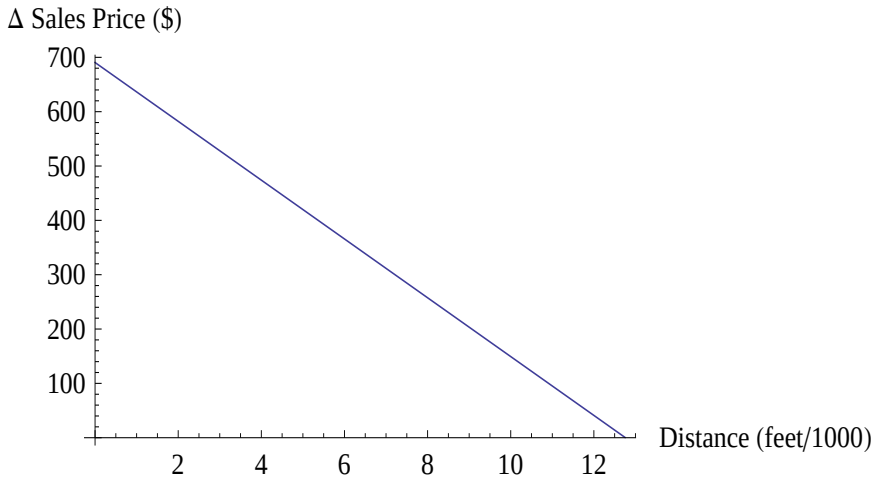


Figure 2.6: Marginal Effect of Distance to the Nearest Antenna on Sales Price



3 A Comparison of Franchised and Independent Real Estate Brokerage Firms

3.1 House Selling, House Buying, and Real Estate Brokers

Purchasing a house is one of the biggest financial decisions a person can make. Only about 9 percent of houses sold in 2012 were for sale by owner; the majority of home buyers work with licensed real estate agents to guide them through the process (National Association of Realtors (2013)), and the majority of agents are affiliated with a franchise (National Association of Realtors (2011a)). Whether it is the seller seeking advice on the appropriate list price and marketing tactics, or the buyer looking for insight about the market value of a property, both sides of the transaction can benefit from working with a real estate professional[1]. Homeowners who decide to list their property with a broker pay a non-trivial sum of money if their property sells. With a median house price of around $208,000 nationally in May 2013, and commissions of, say, 6% of the final sales price, there is $12,480 at stake. Since the commission paid to a real estate broker is the largest monetary cost in selling a house, it is important the homeowner chooses a broker that is able to efficiently locate potential buyers and get a high sales price after a brief time on the market.

3.2 Previous Studies of Agent Behavior, Franchised Brokers: Implications and Findings

While this paper is not the first to study the effectiveness of real estate brokerage firms, or to analyze agent behavior and the incentives they face, it is the first to use actual sales data to compare franchised real estate brokerage firms that have offices across the United States to brokerage firms that are locally owned. Since a franchised brokerage firm can take advantage of national advertising campaigns, there is reason to believe properties listed with these firms are marketed differently and exposed to a wider range of buyers.

[1]Zumpano et al. (1996) show that buyers with high opportunity costs and little information about the local market are more likely to use a broker to search for a house.

They are likely more efficient in reaching potential home buyers that live outside of the local area looking to move into the area. For example, a person selling a house in Florida through the local Florida RE/MAX office can more easily be referred to an agent at a RE/MAX office in Kentucky where that broker helps in finding a new house, even if there is not a price effect. The ability of the franchised broker to match buyers and sellers across broad geographic areas could lead to houses listed with these firms being sold more quickly without sacrificing sales price.

A notable recent contribution to the literature on agent behavior is Levitt and Syverson (2008). They compare sales price and days on market for houses that are agent-owned to sales price and days on market for houses agents list for their clients. They find that agent-owned properties stay on the market longer and sell for more than equivalent houses that are not agent-owned. They show also that the greater the asymmetry is between agent's and seller's knowledge, the larger are the distortions. Beck (2009) does not focus on who owns the property being sold, but rather on the characteristics of the agents and how they impact the sales price and time on market of the houses they sell. Using data from a region in Kentucky similar to the data in this study, he finds that more active agents do sell houses faster, but at the expense of sales price. He also finds that agents who hold a large number of listings at any given time produce slightly lower sales prices. Huang and Rutherford (2007) look at the "Realtor" designation and compare properties sold by agents with and without this designation. They find that properties sold by agents with the Realtor designation are more likely to sell, sell for more, and spend less time on the market than properties sold by agents who do not have the Realtor designation. The attribute this to the access Realtor's have to the Multiple Listing Service (MLS) that non-Realtors are unable to take advantage of, and that the "Realtor" designation represents a signal of quality to which the market responds.

There are a few papers that discuss franchising in real estate brokerage. Using data

collected by the National Association of Realtors, Jud et al. (1994) and Benjamin et al. (2006) compare revenues and profits for franchised and non-franchised real estate brokerage firms. Benjamin et al. (2006) find that franchised real estate brokerage firms generate more revenue but they are not necessarily more profitable than independent brokerage firms, while Jud et al. (1994) find that the initial fees charged by the franchisor are substantially less than the present value of the stream of incremental profits attributed to franchise affiliation[2]. Frew and Jud (1986) use survey data on real estate brokerage firms from three cities in North Carolina to estimate the benefit of franchise affiliation and find results similar to Jud et al. (1994).

While this paper does not focus on the decision to franchise, a discussion of why franchising is a common organization form in the real estate industry is warranted. Anderson and Fok (1998) note that consumers are usually infrequent participants in the housing market and rely on the expertise of real estate professionals to guide them through the process. The brand name associated with a real estate franchise serves as a signal of quality to those who are unfamiliar with the quality of real estate professionals and the local housing market (Anderson and Fok (1998); Brickley and Dark (1987); Rubin (1978); Caves and Murphy (1976); Mathewson and Winter (1985)). The quality assurance provided by a franchise's brand name is most important when consumers are moving to a particular area in which they have no experience in the housing market. If consumers are moving within the same geographic area, they likely have knowledge about the the quality of the local real estate professionals through discussions with others who have experience in the local market. If the market is characterized by mostly local transactions where consumers are moving within the same geographic area, the quality assurance provided by a franchise's brand name would have little value.

[2]They estimate the benefit of affiliating with a franchise to be approximately a 9% increase in annual revenues to the average franchised firm. They do not have data on the net income of firms so they only are able to compare the additional revenue associated with franchise affiliation to the estimated cost of franchise affiliation using industry averages.

Even though the brand name that is associated with a franchise provides a signal of quality and uniformity to consumers, an opportunistic franchisee has an incentive to shirk on the quality of service they provide if doing so can increase their profits (Klein (1980); Caves and Murphy (1976); Rubin (1978); Mathewson and Winter (1985); Brickley and Dark (1987); Anderson and Fok (1998)). In their discussions of company owned versus franchised outlets, Brickley and Dark (1987) and Minkler (1990) suggest that locations that rely heavily on repeat business are more likely to be franchised compared to locations that rely mostly on a transient customer base[3]. If a franchisee caters to mostly non-repeat customers, they can substitute low quality inputs or service for the level of quality required by the franchisor since the consumers will not retaliate by shopping at competitor's location in the future. However, if a franchisee provides low quality to a non-repeat customer, this will diminish the value of the brand name creating a demand externality for all other franchisees operating under the same name. If they do rely heavily on repeat customers, the franchisee must consistently provide quality service to earn the customers future business. In the real estate industry consumers are infrequent participants, however, a firm's reputation can be hurt if they provide low quality service and the affected consumer spreads this information to other potential clients. This internal incentive to avoid shirking and deteriorating the brand name give the franchisor an opportunity to expand without the need for extensive monitoring even when the franchisee serves mostly non-repeat customers.

There is substantial heterogeneity in housing markets across the United States. Franchising allows the local real estate franchisees to gain specific knowledge of the local markets in which they operate while the franchisor specializes in promoting the brand name at the national and regional levels (Caves and Murphy (1976); Minkler (1990); Mathewson and Winter (1985); Anderson and Fok (1998)). Since most states require at

[3]Using distance from a freeway as a proxy for repeat business, Minkler (1990) finds that stores closer to a freeway are more likely to be company owned, while Brickley and Dark (1987) finds that stores closer to a freeway are more likely to be franchised.

least two years of experience before issuing a brokers license, the franchisor can have confidence that the broker/owner operating the franchise will be experienced in the local market. This allows the franchisor to provide managerial advice, training programs for the broker's sales associates, and broader market research to complement the broker's knowledge about the local market (Rubin (1978); Anderson and Fok (1998)). While this is a common explanation for the prevalence of franchising in a variety of industries, housing markets are one area where national and local trends are likely to diverge or even be orthogonal to one another. For example, Carson and Dastrup (2013) report there was considerable spatial variation in housing prices during the Great Recession. Across metropolitan areas, housing prices declined none at all to more than 60%!

This paper breaks from the previous literature by comparing the performance of franchised brokerage firms to independent brokers holding constant the type of agent that listed the property. The focus of this study is on franchised compared to independent brokers rather than agents' characteristics; as in previous studies, performance is measured by the sales price and the time it takes to locate the buyer. Since franchised real estate brokers have access to training programs and referral networks, houses listed with franchised real estate brokers are expected to sell sooner than comparable houses listed with independent brokers; the effect on sales price is indeterminate. This study is also the first to test the hypothesis that franchised sales are more prevalent in areas where consumers are less familiar with the local market using house sales data (Brickley and Dark (1987); Frew and Jud (1986); Anderson and Fok (1998)). Since franchised brokers have access to a nationally recognizable brand name, risk averse consumes that are unfamiliar with the local market should be more likely to work with a franchised real estate broker if they associate the brand name with a certain level of quality. Guided by a model of real estate brokerage that includes listing and selling brokers, this paper compares the performance of franchised and independent brokers. Using detailed data

from sales by both types of brokers, tests are made for differences in local versus out-of-state buyers, list price, sales price, and time on the market.

3.3 A Model of Franchised and Independent Brokerage

3.3.1 The Framework

This section provides a simple model that compares franchised and independent real estate brokers. It builds upon the model of discount brokers in Rutherford and Yavas (2012) by providing functional forms so that explicit solutions can be found. Table 3.1 illustrates the difference in revenues for independent and franchised listing brokers. When a franchised listing broker sells a listed house a certain percentage of the commission must be paid to the franchisor. This royalty is represented in the model by r and is the percentage of gross commission revenue[4]. The revenue to a franchised broker who sells a house as the listing broker is (1-r)kP where k is the percentage of the sale price charged as commission and P is the sales price. When a different broker sells the house, independent and franchised listing brokers pay 1-μ of the total commission to the selling broker and keep μ, where μ is the percentage of the total commission the listing broker keeps when a different broker finds the buyer first. If a different broker finds the buyer first for a franchised listing, the franchised listing broker only pays a royalty on the portion of the commission not given to the selling broker. For any given sales price, the revenue to the homeowner is the same regardless of whether it is listed by a franchised or independent broker and is equal to $(1-k)P$.

Let the probability a property is sold be:

$$\Theta_i(L,S) = \Phi_i(L,S) + \Gamma_i(L,S) \tag{3.1}$$

[4]Royalties typically vary between one and six percent of gross commission revenue, however, some are capped at a maximum dollar amount per agent per year or are a flat dollar amount per month. The typical case is what is modeled here (National Association of Realtors (2011b)).

where i=I indicates an independent broker listing and i=F indicates a franchised brokers listing. Φ_i is the probability that the listing broker finds the buyer, and Γ_i is the probability that a different broker finds the buyer first and the listing broker pays that broker $1-\mu$ of the total commission. L is the effort of the listing broker and S is the total effort exerted by the selling brokers. This specification is similar to Rutherford and Yavas (2012) where they let S be the average effort of potential selling brokers. This model allows for n selling agents which means S is the sum of effort exerted by the selling brokers ($S = \sum s_j$ where s_j is the effort of selling broker j).

Let the functional form for $\Theta_i(L,S)$ be[5]:

$$\Theta_i(L,S) = \underbrace{\frac{\alpha_i^l L}{1+\alpha_i^l L+\alpha_i^s S}}_{\Phi_i} + \underbrace{\frac{\alpha_i^s S}{1+\alpha_i^L L+\alpha_i^s S}}_{\Gamma_i} \tag{3.2}$$

Φ_i is increasing in L and decreasing in S, Γ_i is increasing in S and decreasing in L, and $\partial^2\Phi_i/\partial S\partial L \neq 0$ and $\partial^2\Gamma_i/\partial L\partial S \neq 0$. This type of contest success function ensures that the more effort the listing agent (selling agent) exerts, the probability the listing agent (selling agent) finds the buyer first increases and the probability the selling agent (listing agent) finds the buyer first decreases. This functional form also ensures that Θ_i is concave in L and S and is strictly less than one[6].

These functional forms are proposed in Blavatskyy (2010) and are shown to be the only functional forms to possess the important characteristics needed for contest success functions in this setting. The most important property is that the relative probabilities of winning are homogeneous of degree 0, i.e, $\frac{\Phi(L,S)}{\Gamma(L,S)} = \frac{\Phi(\lambda L,\lambda S)}{\Gamma(\lambda L,\lambda S)}$. This says that if both listing

[5]Notice that the ratio Φ/Γ=$\alpha_i^l L/\alpha_i^s S$. If $L = S$, this ratio equals α_i^l/α_i^s which can be estimated using the sales data. Since the percentage of properties sold by the listing broker is known for both types of brokers, this can be used as the estimate for α_i^l and can be estimated using $\alpha_i^s = 1-\alpha_i^l$.

[6]Since listed properties do not sell with certainty there has to be a third state of the world in this model where neither the listing broker or a different broker locates a buyer. With these functional forms, the probability a buyer is not found is $\frac{1}{1+\alpha_i^L L+\alpha_i^s S}$.

and selling agents increase their effort by the same amount, the relative probabilities of them winning remains the same. This property also ensures that the probabilities are not sensitive to the units in which effort is measured. The second property is that if either agent exerts zero effort, the probability of that agent finding the buyer first is zero. So long as one of the agents exerts positive effort, there is a positive probability of the property being sold. For example, when a property is listed at the lower end of the price distribution there may not be incentive for anyone other than the listing agent to locate a buyer. Because of the way commissions are split between agents and their brokers, the net payoff of selling a low-priced house listed with a different firm could be less than what is necessary to encourage other selling brokers to try and locate a buyer[7].

In this model, the probability of buyers being located differs from those presented in Rutherford and Yavas (2012). They present only two probability functions. The first is $\Theta(L, S)$ which is the probability the buyer is found, and $\Phi(L, S)$ which is the probability that the listing agent finds the buyer first. Since the listing agent keeps the entire commission (kP) only if the buyer is located before a different selling broker, a third probability function is necessary. The probability of this event is missing from their model[8]. They also assume that $\partial^2\Theta/\partial L\partial S = 0$ along with being concave in L and S. Since the contest success functions used here have been shown to be the only functional form to possess the characteristics needed for contest success functions in this setting, the assumption that the cross partial is equal to zero should be reconsidered.

[7]Levitt and Syverson (2008) discusses this in the context of agent-owned vs. non-agent-owned listings.

[8]This can be seen by looking at the expected payoff functions for the discount and full service listing brokers on pages 8 and 9 in Rutherford and Yavas (2012). The probability that a buyer is found by a different broker and the listing broker has to pay μ of the total commission in the expected payoff function is overstated by $\Theta - \Gamma$.

The objective function for the homeowner is:

$$\max \begin{cases} \max_{P_F} \int_{P_F}^{B} \Theta_F(L,S)(1-k)P_F dF(P_b) \\ \max_{P_I} \int_{P_I}^{B} \Theta_I(L,S)(1-k)P_I dF(P_b) \end{cases} \tag{3.3}$$

where the F subscript indicates a franchised broker, I indicates an independent broker, and $\Theta(L,S)$ is defined as in (3.2) above. P_F and P_I are the take-it-or-leave-it list prices chosen by the homeowner under a franchised or independent listing, and k is the percentage of the sales price paid to the listing broker if the buyer is found[9]. $F(P_b)$ is the distribution of potential buyers' reservation prices and is the same for both franchised and independent listings[10]. Reservation prices are assumed to be distributed uniformly on the (0,B) interval where B is the maximum reservation price of the potential buyers[11].

The objective functions for the two types of listing agents are:

$$\max_{L} \int_{P_F}^{B} \Phi_F(L,S)(1-r)kP_F dF(P_b) + \int_{P_F}^{B} \Gamma_F(L,S)(1-r)\mu k P_F dF(P_b) - C_F(L) \tag{3.4}$$

$$\max_{L} \int_{P_I}^{B} \Phi_I(L,S)kP_I dF(P_b) + \int_{P_I}^{B} \Gamma_I(L,S)\mu k P_I dF(P_b) - C_I(L) \tag{3.5}$$

Where r <1 is the percentage of revenue generated by the listing broker that must be paid to the franchisor, μ is the percentage of the total commission that is kept by the listing broker if a different broker finds a buyer first, and $C_i(L)$ is a strictly increasing cost of effort function with constant marginal cost c_i. Φ and Γ are the probabilities of the listing and selling brokers finding the buyer first and are given in (3.2) above. The first term is the expected revenue when the listing broker locates the buyer first, and the second term is the

[9]The negotiation process is excluded from this model.

[10]All potential buyers in the model are assumed to be identical and are indifferent between franchised and independent firms listings.

[11]Other distributions were used and the results were similar. The uniform distribution was used for its computational simplicity.

expected revenue when a different selling broker locates the buyer first and the listing broker must pay them 1-μ of the total commission.

Selling brokers have the following objective functions:

$$\max_S \int_{P_F}^{B} \Gamma_F(L,S)(1-\mu)kP_F dF(P_b) - C_F(S) \tag{3.6}$$

$$\max_S \int_{P_I}^{B} \Gamma_I(L,S)(1-\mu)kP_I dF(P_b) - C_I(S) \tag{3.7}$$

where $C_i(S)$ is a strictly increasing cost of effort function with constant marginal cost c_i, and Γ_i, μ, k, and P_i are the same as described above. Notice that the revenues for both types of brokers are identical, but they have different probability and cost functions[12].

3.3.2 Effort Levels of Listing and Selling Brokers and Best Reply Functions

The game between the homeowner, listing broker, and selling broker is demonstrated in Figure 3.1. For each type of listing, the listing and selling brokers will choose their levels of effort simultaneously[13]. The homeowner will then observe these levels of effort and then choose a list price to maximize equation (3.3). Whichever type of broker gives the higher expected payoff to the homeowner will then get the listing. Since the functional forms lead to intractable solutions, they are demonstrated graphically using parameter values consistent with the MLS data that will be used later. The best reply functions for the listing and selling brokers are given in the appendix.

Figures 3.2 and 3.3 show the best reply functions for each type of listing when the commission charged is 6%, the franchise fee is set to 5%, there is a 50/50 split of the total

[12]When a franchised broker locates the buyer for another broker's listing, the franchised broker still has to pay a royalty to the franchisor on the portion of commission that they receive. To avoid adding a third player to the game, only one type of selling broker is represented in the model. Selling brokers are allowed to exert different levels of effort depending on the type of broker that lists the property.

[13]In the stylized extensive form of the game shown in Figure 3.1, the listing and selling brokers choose between a high or low level of effort. In practice, the listing and selling brokers choose any level of effort greater than or equal to zero.

commission when a different broker finds a buyer, the marginal cost of effort is equal to 100, and there is only one selling broker[14]. Other combinations of parameter values were used and each gives qualitatively similar best reply functions. In this type of game, the effort levels of the listing and selling brokers are strategic substitutes. This follows from the probability function shown in equation (3.2) above where the marginal increase in the probability of finding the buyer first for the listing broker (selling broker) is decreasing in the level of effort exerted by the selling broker (listing broker). This leads to the downward sloping best reply functions shown in Figures 3.2 and 3.3. Figures 3.4 and 3.5 show the best reply functions when there are five identical selling brokers. Notice that the effort exerted by the listing broker does not change when the number of selling brokers increases. The selling brokers reduce their effort proportional to the number of selling agents in the market (the effort exerted by a selling broker is one-fifth of the effort level when there was only one selling broker). Since the listing broker is competing against the sum of efforts exerted by the selling brokers to locate the buyer, the listing brokers exert the same amount of effort whether they are competing against one broker exerting S_1 units of effort or n selling brokers each exerting S_1/n units of effort. As the number of selling agents increase, the probability that an individual selling broker locates the potential buyer decreases, reducing the return on their effort. This leads to each individual selling brokers exerting less effort to locate the potential buyer.

Figures 3.6 and 3.7 show the expected revenue for the homeowner as a function of the list price chosen using the same parameter values that were used to derive the best reply functions in Figures 3.2-3.5 and a maximum reservation price for potential buyers of $100,000. Notice that the list price that maximizes the homeowner's payoff is the same for both types of listings and is equal to $50,000. This value is equal to $B/2$, the average reservation price for potential buyers assuming reservation prices are uniformly

[14] All of the parameter values except for B, c_i, and P_i come from the data or stylized facts about the local real estate market.

distributed between zero and B[15].

Tables 3.2a and 3.2b show the theoretical model's estimates of the effort, probabilities of finding a buyer first, and the homeowner's payoff using two sets of parameter values. The only difference in the two sets of estimates is that in Table 3.2b the marginal cost for franchised brokers is less than that of independent brokers. When the marginal cost of effort is the same for franchised and independent brokers, efforts are such that the homeowner is better off listing with an independent broker. Because the franchised brokers have to pay a franchise fee of r on all commissions generated, this discourages effort and leads to a lower expected payoff to the homeowner. In Table 3.2b, even though they still have to pay the franchise fee, they are assumed to have a lower marginal cost of effort. This works in the opposite direction of the franchise fee and increases the effort levels to a level where it is now in the homeowner's best interest to list with a franchised broker.

3.3.3 Different Marginal Costs of Effort for Independent and Franchised Brokers

In this model the marginal cost of effort for franchised brokers is assumed to be less than the marginal cost of effort for the independent brokers. There is good reason to believe this assumption is appropriate. Using data from the 1994-1995 National Association of Realtors' nationwide survey Lewis and Anderson (1999) estimate a cost frontier and Anderson et al. (2000) estimate cost and profit frontiers to determine the efficiency of real estate brokerage firms. Both studies find that franchised real estate brokerage firms are more efficient from a cost perspective compared to independent brokers and list brand recognition as a reason for increased efficiency. If potential buyers are unfamiliar with the market they are moving into and are uncertain about the quality of real estate brokers in the area, they will be more likely to seek out a "brand name" brokerage firm if they

[15]Given the properties of the functional forms given in equation 3.2, an analytical proof of this is not possible at this point. Different combinations of parameter values were used and similar results were found.

associate that name with a guaranteed level of quality. This behavior results in less effort having to be exerted by the franchised brokers since potential buyers select into franchised brokerage firms reducing the amount of effort needed to locate potential buyers.

Some buyers choose to work with a franchised broker because of the quality associated with their franchise; however, some choose to work with them simply because they were referred by the broker where they are currently selling a house. If the person is working with a particular franchise where their current house is for sale, the listing broker can easily refer them to a broker with the same franchise where they are moving. The effect of referrals is similar to buyers seeking out a franchised broker due to brand loyalty and could result in even more efficiency gains. If the broker where the person is selling a house can inform the broker they are currently working with of their preferences for characteristics such as house size, price range, and amenities, they can seek out suitable properties before ever meeting the potential buyer. Time that would be spent meeting with the client and getting a feel for their preferences can be spent looking at houses that are more likely to match the consumer's preferences.

In addition, each of the franchises that are represented in the sample offer training for their agents and brokers and technology that assists in marketing listed properties and locating buyers[16]. Training courses focus on areas such as advertising, sales techniques, referrals, and business operations, while technology training focuses on topics such as advertising on mobile devices, website design, and lead and referral systems. Training, technology, and the previous cost-saving advantages of franchised real estate brokers mentioned lead to the following: franchised brokers have advantages in making potential buyers aware of their own listings and locating buyers for all listings. While some skills agents acquired while working for a franchised real estate firm are transferable and could be used in independent brokerage firms if the agent chooses to leave (marketing and sales techniques,

[16]This training is described on the websites of each franchise in the sample.

and business operation), the primary time-saving advantages such as the referral network, lead generating systems, and the national advertising campaign only benefit those agents working for that particular franchise.

3.4 Testable Implications from the Model of Brokerage and the Literature

3.4.1 Implications of the Model

The theoretical model presented above provides two testable hypotheses. The first is that houses listed franchised brokers and houses listed with independent brokers will have the same list price for a given house. Figures 3.6 and 3.7 show that the homeowner chooses the same list price to maximize their expected revenue regardless of the type of broker they choose to list the property.

The second is that franchised brokers sell their own listing less often than independent brokers which is shown in Tables 3.2a and 3.2b ($\Phi_F < \Phi_I$). In Table 3.2b where franchised brokers are assumed to have different marginal costs of effort, the model predicts that the franchised broker will find a buyer for their own listings approximately 5% less often than an independent broker. The percentages of properties sold “in house" for each type of listing broker are compared to test this prediction.

3.4.2 Implications from the Literature

Levitt and Syverson (2008) compared the sales price and days on market for houses that were agent-owned to the sales price and days on market for houses that agents listed for their clients. Since the agents have more knowledge about the local real estate market, they predict and find that agent-owned houses stay on the market longer and sell for more than non-agent-owned properties. In this paper, franchised real estate brokers are able to take advantage of a nationally recognized brand name, nationwide advertising campaigns,

lead generating systems, and large referral networks. If these assets give franchised real estate brokers an edge over independent brokers, a franchised broker should be able to match buyers and sellers more efficiently than independent brokers. This leads to the another testable hypothesis: houses listed with franchised brokers should sell quicker than comparable houses listed with independent brokers, but the effect on sales price is indeterminate. If franchised brokers sell houses sooner without a reduction in sales price, this implies they are indeed more efficient than independent brokers. Homeowners who list with franchised brokers can still be made better off even if the quicker sale results in a slightly lower sales price depending on the size of the reduction in sales price. A framework similar to Levitt and Syverson (2008) will be used to estimate the tradeoff between sales price and the time it takes to locate a buyer for franchised and independent brokerage firms.

Brickley and Dark (1987) argue that in general consumers less familiar with the local market will choose a franchise if they associate the franchise with a certain level of quality, and Frew and Jud (1986) and Anderson and Fok (1998) make the same argument specifically for real estate brokerage services. This provides another testable hypothesis. If consumers relate the nationally recognized brand names and nationwide advertising campaigns associated with franchised selling brokers as a signal of quality, franchised brokers should be more active in areas where more residents are moving from out of state. Even if local independent brokers have more knowledge of the local real estate market, the brand name associated with a particular franchise gives a signal of quality that the consumer can identify. A similar result will be found even if the consumers moving from out of state do not associate advertising and brand names with a certain level of quality, but they are referred to the franchised broker by a broker where they are currently living. To test this hypothesis, each property's location is used to determine the number of residents near each property that moved from out of state.

3.5 Data and Specifications for Estimation

3.5.1 Data on the Markets for Real Estate Brokers and Housing

The data cover 12 years from 2000-2011 and were extracted from two Multiple Listing Services that serve the central region of Kentucky. The data provide an extensive set of structural characteristics, closing dates, sales and list price[17], and the agent and office responsible for the listing and sale for each property sold[18]. These data are much richer than the data used in previous studies on franchising in real estate brokerage. Benjamin et al. (2006), Jud et al. (1994), and Frew and Jud (1986) all use survey data to compare revenues and profitability for franchised and independent real estate brokers and are unable to control for type and location of the houses sold by the firms in their regressions. They show that franchised brokerage firms generate more revenue for themselves, but are unable to show whether or not listing with a franchise can provide the homeowner with a higher price or a quicker sale holding constant the structural characteristics and location of the property being sold; this study is the first to answer those questions.

Table 3.3 shows the share of listing and selling agents, and the share of observations in the sample for each franchise and for the largest independent firm[19]. The percentages shown in Column 4 suggest that the higher average number of selling agents for the independent brokers is due in large part to the largest independent firm in the sample. Twenty-two percent of all selling agents work for the largest independent firm, and not surprisingly, the largest independent firm has the highest probability of selling their own listing. Table

[17] All sales prices were converted to average 2011 dollars using the CPI.

[18] All properties with less than 500 square feet or more than 10,000 square feet, or zero bedrooms or zero full baths were dropped. Observations that were clearly miscoded were also dropped. This includes houses with an abnormally large or small number of bedrooms or bathrooms for the sales price, houses with missing agent or broker information, and houses that were not successfully geocoded into census tracts.

[19] More franchises show up in the dataset, however, this study is limited to the four largest franchises as measured by the total number of sales associates and brokers according to the latest comparison of residential real estate franchises available at Realtor.org. The four franchised firms included in the sample make up 92% of all franchised listings in the dataset.

3.3 also shows that RE/MAX lists and sells a disproportionate number of houses given their percentage of listing and selling agents in the market.

Brokers who are affiliated with Century 21, Coldwell Banker, and Keller Williams all pay a royalty of 6% of gross commission, while RE/MAX brokers pay a fixed fee of $125 per month per agent and 1% of gross commissions[20]. While the total investment to start up a franchise with each company is hard to predict and depends on many factors, Century 21 and Coldwell Banker require a 10 year commitment, and Keller Williams and RE/MAX have 5 year terms. Consistent with Caves and Murphy (1976), to ensure the local franchises are not free riding off of the national advertising campaigns and brand name, each franchisor requires their franchisees to pay a fixed fee per agent or an ongoing percentage of commission for advertising. RE/MAX and Keller Williams have fixed fees of $101 and approximately $30 per month per agent, respectively, while Century 21 charges 2% of monthly gross revenue subject to a monthly minimum and maximum of $651 and $1,508, and Coldwell Banker charges either 2.5% of gross revenue up to $2,000,000 and 0.5% of gross revenue over $2,000,000, or 2.5% of gross revenue monthly with a minimum and maximum of $88 and $1,388.

The financial arrangements between the owners of the franchise and the franchisors will play some role in the performance of their sales associates, however, the compensation structure and training programs are arguably the most relevant factors. While all four franchises advertise nationally, Keller Williams heavily allocates resources to build a local brand identity and supports their agents at the local level. Keller Williams also is one of the few franchises to offer a profit sharing program which paid out nearly $35 million to their associates in 2010 (Wakefield (2011)). Sales associates affiliated with Century 21, Coldwell Banker, and Keller Williams split their commission with their broker starting at a

[20]The figures for Century 21, Coldwell Banker and RE/MAX are from from previews of the Franchise Disclosure Documents filed with the Federal Trade Commission on franchisedirect.com. The figures for Keller Williams are from entrepreneur.com.

split of around 50/50 and becoming more generous as the level of commissions generated rise. RE/MAX offers their associates the option splitting commissions similar to the other franchises, however, they also provide the option of keeping 100% of commissions earned in exchange for fixed monthly fees to cover advertising, administrative costs, and the brokers fees. While this structure is likely to entice agents who generate high gross commission to join RE/MAX over a different franchise with a less generous commission structure, the RE/MAX logo is arguably one of the most recognizable corporate symbols in the world giving below-average agents something associate with as the begin their real estate careers. Whether or not it is above or below-average agents that choose to affiliate with a franchise is an empirical question that will be discussed below.

The sample averages for transaction and house characteristics by listing broker type are shown in Table 3.4[21]. Independent brokers on average list houses for $5,439 (3.2%) more than franchised brokers, and have a sales price of $6,150 (2.9%) more. While the list and sales prices are statistically and economically different, this difference does not appear to be driven by the two types of brokers selling different types of houses[22]. Assuming the difference in sales price and days on market is not a function of the neighborhood characteristics in which the house is located, waiting an additional 1.5 days for a 2.9% increase in sales price implies an annual return of 702%[23]! Yelowitz et al. (2013) show that some firms specialize in certain segments of the market. If the independent brokers are specializing in better neighborhoods (holding constant the type of houses), then the raw difference in means shown in Table 3.4 is overstating the performance of independent listing brokers[24].

[21] Summary statistics for the full sample are given in Table A2.1.

[22] There are statistically significant differences in the housing characteristics, however, the houses listed by each type are economically insignificant.

[23] If $(1+r/365)^{1.5}=1.029$, r=7.023.

[24] The summary statistics in Table A2.2 separate the largest and small independent brokers. The summary statistics show that franchised listing brokers list and sell houses for a little more than small independent brokers, but less than the largest independent broker. They also show that franchised brokers sell their own listing less often than both large and small independent brokers, and that they sell homes quicker than small independent brokers but not as quick as the largest independent broker.

Following Rutherford and Yavas (2012), “Degree Overpricing" is the residual from a sales price regression that includes housing characteristics, year-month dummy variables, and census tract fixed effects. It measures how over or underpriced a particular house is based on the average price of a house with similar characteristics. The summary statistics show that houses listed with independent brokers tend to be priced above the average list price of a similar house while houses listed with the franchised brokers are underpriced. This difference is consistent with the days on market where houses listed with franchised brokers are sold slightly sooner than those listed with independent brokers[25].

An important attribute of data used is that the exact address of each sold property is known allowing the sales data to be merged with data from the United States Census.“% Out of State 5 Years Ago" is the estimate of the percentage of residents in each census tract that moved from out of state from the 2000 Census long form, and “% Out of State 1 Year Ago" is defined similarly but comes from the 2010 American Community Survey 5 year estimates. “5 Miles Ft. Knox" is a dummy variable equal to one if the property is located within five miles of the Ft. Knox military base and is used as a proxy for the number of out-of-state movers. All three measures suggest that franchised brokers are more active in areas where a larger share of the population moved from out of state[26]. This is consistent with Rubin (1978), Minkler (1990), Frew and Jud (1986), and Anderson and Fok (1998) which all argue that if consumers who are less familiar with the quality of local establishments associate familiar franchises with a certain level of quality, they will be more likely to patronize franchised compared to a locally owned businesses. These data allow for a first test of this hypothesis using data from housing markets.

The rich data allow for formal tests of the performance of franchised and independent

[25]The probability that a house is sold (Equation 3.2) is measured by days on market.

[26]In Table A2.2 where the largest independent broker and small independent brokers are separated, both Census measures of the percentage of out-of-state movers show that franchised brokers appear to be more active in areas with a higher percentage of out-of-state movers compared to the small independent brokers, but less active than the largest independent broker.

brokerage firms. A simple comparison of means is not sufficient since independent and franchised brokerage firms could specialize in different market segments (Yelowitz et al. (2013)). Previous studies on franchising in real estate brokerage use firm level survey data that do not include any information on the types and location of houses being sold. The data used in this study include an extensive set of structural characteristics, precise location information, and the agent responsible for each sale. This ensures that the estimated partial effect of listing a property with a franchised broker is not biased due to the type and location of houses they list or the agents they employ.

3.5.2 Empirical Specifications

The first empirical specification follows the theoretical model's result that the list prices for franchised and independent brokers are the same (Figures 3.6 and 3.7)[27]. The following regression is estimated:

$$ln(\text{List Price})_{ijt} = \text{Franchised}_{ijt}\omega + x_{ijt}\psi + \sigma_t + \delta_j + \epsilon_{ijt} \tag{3.8}$$

where $ln(\text{List Price})$ is the natural log of the list price for house i sold at time t in area j. Franchised_{ijt} is a dummy variable equal to one if a franchised firm listed the property, x_{ijt} contains structural characteristics of the property and an intercept term, σ_t are time dummy variables, δ_j are location dummy variables, and ϵ_{ijt} is the error term. In the first regression Franchised_{ijt} will contain a single dummy variable that equals one if a franchised firm listed the property to measure the average effect a franchised listing broker has on the sales price. In the second regression each franchise will have a separate intercept term to allow for heterogeneity across different franchises. If the list prices for franchised and independent listings are the same, ω in (3.8) will not be statistically different from zero.

The second specification follows from the theoretical model's result that franchised listing

[27] A comparison of the sales prices for franchised and independent listing brokers will be presented below.

brokers find buyers for their own listings less often than an independent listing broker. A problem with simply comparing the means of listings sold in house for the different types of broker is that one type of broker could systematically list houses that are more attractive to potential selling brokers. The best measure is a regression that holds constant the characteristics of the house and its location.

$$\text{SoldOwn}_{ijt} = \text{Franchised}_{ijt}\rho + x_{ijt}\psi + \sigma_t + \delta_j + \epsilon_{ijt} \tag{3.9}$$

where SoldOwn is a dummy variable equal to one if the listing broker also found the buyer. Franchised_{ijt} is a dummy variable equal to one if a franchised selling broker located the buyer, x_{ijt} contains the structural characteristics of the property and an intercept, σ_t are time dummy variables, δ_j are location dummy variables, and ϵ_{ijt} is the error term. If franchised listing brokers find buyers for their own listings less often than independent listing brokers, ρ <0 in (3.9).

The performance of franchised and independent brokers will be compared on two dimensions: sales price and days on market. Homeowners are likely to perceive a tradeoff between sales price and the length of time the property is on the market and will be willing to accept a lower price for a quicker sale. Some homeowners are more patient than others and are willing wait for an offer closer to list price. One way to see if a firm is more efficient than another is to compare the sales prices, along with the time it takes to locate a buyer, for different listing brokers. To test this, the natural log of sales price and the days on market are regressed on an extensive set of structural characteristics, year-month dummy variables, census tract fixed effects, and dummy variables indicating whether the property was listed by a franchised brokerage firm. If the franchised brokerage firms are able to get the homeowner a sales price greater than or equal to the independent firms, and get the property off the market sooner, this would indicate they are indeed more efficient. Homeowners can still be made better off if the quicker sale results in a lower sales price if

the reduction is small relative to the length of time it takes to locate a buyer. Since there is no direct tradeoff between the sales price and days on market, rather a tradeoff between the list price of comparable houses (Anglin et al. (2003)), the degree of overpricing (DOP) is included in the days on market regression. If a house is substantially overpriced compared to similar houses on the market, this tends to increase the time it takes to locate a potential buyer[28]. The following regression is estimated:

$$Y_{ijt} = \text{Firms}_{ijt}\omega + x_{ijt}\psi + DOP\zeta + \sigma_t + \delta_j + \epsilon_{ijt} \tag{3.10}$$

where Y_{ijt} is either the natural log of the sales price or days on market. Firms_{ijt} is a vector of dummy variables indicating the listing and selling firm of the house, x_{ijt} contains the structural characteristics of the house and an intercept, σ_t are time dummy variables, δ_j are location dummy variables, and ϵ_{ijt} is the error term.[29].

In the first specification, Firms_{ijt} contains dummy variables indicating whether or not the property was listed or sold by a franchised broker and estimates the average effect of a franchise listing broker on the sales price and the length of time it takes to locate a buyer compared to all independent brokers. The second specification adds dummy variables indicating whether or not the house was listed or sold by the largest independent broker so the franchised listings are compared to small independent firms. The third specification allows each franchise to have a separate intercept to allow for heterogeneity across different franchises.

To see if the difference in performance of the franchised brokers is driven by the types of agents who choose to affiliate with them, specifications one through three are re-estimated

[28] It is important to note that overpriced does not imply expensive. A house priced at $150,000 could take much longer to sell than a $300,000 house if the $150,000 house is priced 30% higher than a comparable house and the $300,000 house is priced 30% less than a comparable house. The degree of overpricing variable holds constant the price of the house compared to other properties that could be considered substitutes.

[29] ζ is set to zero in the sales price regression.

but fixed effects indicating whether or not the listing agent has, is, or ever will be affiliated with a franchise are included. The first listing agent specification includes a dummy variable indicating whether or not the listing agent has, is, or ever will be affiliated with a franchised real estate broker and estimates the average effect of these agents. Since the agents who choose to work for a franchised brokerage firm could be fundamentally different from those agents who choose to work for an independent broker, it is important to hold constant the agent characteristics to isolate the “brand name" effect of the franchise. Since this variable is equal to one for houses listed with agents working for independent brokers who have, or will work for a franchised broker at any time during the sample period, it is not perfectly correlated with the variable indicating a property is listed with a franchised broker[30]. In the second and more flexible listing agent specification, each agent who is has been affiliated with a franchise at any point during the sample period has a separate intercept. This allows for heterogeneity among the listing agents who have been affiliated with a franchise at any point during the sample period.

To focus on franchised brokerage firms' presumed ability to more efficiently match out-of-state buyers and sellers, linear probability models are estimated where the dependent variable is equal to one if the property was sold by any of the three franchised brokerage firms (SBF) in the sample[31]. Separate regressions are estimated using each of the three measures of out-of-state movers as independent variables along with the extensive set of structural characteristics, location fixed effects (when possible), and year-month dummy variables. Formally, the following regression is estimated:

$$\text{SBF}_{ijt} = \text{OutOfState}_{ijt}\gamma + \text{Firm}_{ijt}\Delta + x_{ijt}\beta + \sigma_t + \delta_j + \epsilon_{ijt} \tag{3.11}$$

[30] 30% of the agents in the sample worked for independent and franchised brokers.

[31] “Sold by a franchised broker” refers to the situation in which franchised broker acted as the selling broker in the transaction. Probit regressions were also ran and the results are reported in the appendix. The results are qualitatively similar. For ease of interpretation, the linear probability model estimates are presented and discussed.

where OutOfState$_{ijt}$ is the measure of out-of-state movers, Firm$_{ijt}$ is a dummy variable equal to one if a franchised broker listed the property, x_{ijt} contains the structural characteristics of the house and an intercept, σ_t are time dummy variables, δ_j are location dummy variables, and ϵ_{ijt} is the error term. The first measure of out-of-state movers is a dummy variable equal to one if the property is located within five miles of the Fort Knox military base[32]. Even though there are properties bought and sold near the base that do not belong to military personnel working there, people moving to that area are more likely to be relocating from out of town than people moving to other places in the area if they are employed at the base. If these consumers are unfamiliar with the quality of the local real estate brokerage firms, and they associate the brand name with a certain level of quality, they will be more likely to work with a franchised real estate broker. If the probability of the house being sold by a franchised brokerage firm is increasing the closer it is to Fort Knox, this gives some credibility to the argument that these types of firms are better able to match buyers and sellers not residing in the same geographic area, and that non-local buyers may gain a sense of quality assurance by working with a franchised brokerage firm.

The last two measures use census tract level data on migration from the 2000 Census and the 2010 American Community Survey (ACS). One issue is that the ACS and 2000 Census long form questions are slightly different. The 2000 long form question asked “Did this person live in this house or apartment 5 years ago (on April 1, 1995)?". If they answered “No" they were asked about the city, county, state, and zip code of their previous residence. One problem with this is that this question is likely be identifying people that lived in a different state 5 years ago but their most recent move was within the same city, county, or state. The 2010 ACS 5 year estimates are based on the question “Did this person live in this house or apartment 1 year ago?". If the respondent answered “No, different house in the United States or Puerto Rico" they were asked the city, county, zip

[32] A search was done to see which distance from Fort Knox maximized the R^2. While the R^2 did not change for the different specifications, five miles was chosen because it had the correct sign and with the smallest standard error.

code, and state where they previously lived. Summary statistics are provided in Table 3.4 for both measures.

3.6 Results

3.6.1 List Price and Sold Own Listing

Estimates from regressions comparing the list prices of houses listed with franchised and independent brokers are shown in Columns 1 and 2 of Table 3.5 [33]. This regression allows for a test of the prediction that list prices are equal. Column 1 indicates that houses listed with franchised brokers are listed for approximately 1.3% less than houses listed with independent brokers and is inconsistent with the prediction of the theoretical model. Franchised listing brokers appear to be strategically underpricing their houses for a faster sale and a slightly lower commission compared to independent brokers. In Column 2, each franchise has a separate intercept. The results indicate that there is variation across franchises in how their list prices compare to independent listing brokers. RE/MAX, Coldwell Banker, and Century 21 all list houses for less than a comparable house listed with an independent broker, however, Keller Williams lists houses 6.8% more than a comparable house listed with an independent broker. Even though Keller Williams lists comparable houses for 6.8% more than an independent broker, their market share of listings is too small (1.4%) to raise the average list price for franchised listing brokers to a level equal to the average list price of independent listing brokers[34].

Columns 3-4 of Table 3.5 report OLS estimates that allow for a test of the theoretical

[33]The full output is shown in Table A2.3.

[34]The results in Table A2.4 include a dummy variable equal to one if a house was listed with the largest independent broker. When small independent brokers are the comparison group, there is not enough evidence to say that franchised and small independent listing brokers choose different list prices. Coldwell Banker, the largest independent broker, and Keller Williams list houses for about 0.60%, 8.0%, and 4.4% more than a small independent broker, respectively. RE/MAX and Century 21 list houses for 0.40% and 1.7% less than a small independent broker.

model's second prediction[35]. These estimates report the differences in the probability of selling one's own listing holding constant the structural and neighborhood characteristics of the property. Since Table 3.4 shows that independent listing brokers have more than twice the number of selling agents than franchised listing brokers, the number of selling agents in the listing firm is included to hold constant the effect firm size could have on the probability of a broker selling their own listing. Column 3 shows franchised firms are about 2.1% less likely to sell their own listing compared to independent listing brokers holding constant the number of selling agents in the listing firm. Comparing Φ_I to Φ_F in Table 3.2b, the theoretical model predicts that a franchised listing broker is about 5% less likely to find a buyer first compared to an independent listing broker. While the sign is consistent with the theoretical model, the coefficient is approximately two-fifths the size of the theoretical model's prediction, but almost identical to the difference shown in Table 3.4. Since the theoretical model is very stylized and does not take into account the number of selling agents in each firm, it is reassuring that the empirical estimate is smaller than the prediction from the theoretical model[36].

3.6.2 Sales Price and Days on Market with and without Agent Fixed Effects

The effect on sales price of listing with one of the franchised brokerage firms when the omitted brokerage type is all independent brokers is shown in Column 1 of Table 3.6[37]. While the effect structural housing characteristics have on sales price is not the focus of this study, it is important to point out that the coefficients are sensible and consistent with other studies. The sales price is increasing in the number of bedrooms, full bathrooms, partial bathrooms, square footage, lot size, and is decreasing in age. Having a fireplace,

[35]The marginal effects from a probit regression are shown in Table A2.14 in Columns 1 and 2.

[36]The theoretical model was calibrated using the percentage of own listings sold given in Table 3.4. The ratio of own listing sold to listings sold by a different broker is equal to α_i^l/α_i^s when L=S. If the listing and selling agents in the sample are exerting different levels of effort, the theoretical and empirical estimates will be different. In Table A2.4 where the comparison group is small independent brokers, the results still show that franchised brokers are less likely to sell their own listing.

[37]The full output is shown in Table A2.5.

basement, central air conditioning, a brick exterior, or a garage or carport lead to a higher sales price. Even though a more extensive set of structural characteristics are used in this study, the results are consistent with the estimates in Beck (2009) and Levitt and Syverson (2008). Each of those studies use categorical variables to for the number of bedrooms, bathrooms, house size, and lot size and find that increases in each of these variables lead to a higher sales price. The results in this study show that a house with a fireplace sells for 4.9% more than a house without a fireplace while Beck (2009) finds that the presence of a fireplace increases the sales price by 3.8%. Levitt and Syverson (2008) finds that brick exterior adds 3.3% to the sales price compared to 4% in this study.

The estimates in Table 3.6 show that listing a house with a franchised listing broker leads to a 1.3% reduction in sales price for the homeowner holding constant the structural and neighborhood characteristics of the house being sold. This reduction is less than half of the difference in average sales price shown in Table 3.4 and suggests that some of the difference in the sales price can be attributed to the neighborhoods in which they list and sell houses. This result is consistent with Yelowitz et al. (2013) who find that some firms specialize in particular segments of the market. While listing with a franchised broker leads to a lower sales price, franchised brokers do sell houses approximately 3.6 days sooner (Column 2). To put this in perspective, a homeowner would need an annual return on their investment of 131% to be indifferent between selling their house 3.6 days sooner at a reduction in sales price of 1.3% and waiting 3.6 days and not taking the discount[38]. When the reference group is only small franchised listing brokers, franchised listing brokers still locate a buyer about 3.6 days sooner, but for only 0.4% less than a small independent broker. Listing with the largest independent broker leads to a 3.9% increase in sales price compared to a small independent broker. Using the average sales price from Table A2.1, listing with a franchised broker leads to a decrease in sales price between $670 and $2408, while listing with the largest independent broker leads to an increase of

[38]If $(1+r/365)^{3.6}=1.013$, $r=1.31$.

$7,042[39].

The results in Table 3.6 suggest that homeowners would be better off listing with a large or small independent real estate broker, however, the results could be due to the the types of agents working in each type of firm and not the organizational structure of the firm. Table 3.7 includes a dummy variable equal to one if the listing agent has, is, or will be affiliated with a franchised listing broker at any point during the sample period. There are a few reasons why the agents who affiliate with a franchise be different than those who do not. For example, a new agent decides to affiliate with a franchise to take advantage of their training programs and brand name recognition as they establish themselves in the market, while a more experienced agent chooses to affiliate with a franchise to take advantage of a more generous commission split with their broker. If the agent leaves the franchised broker for an independent broker, some of the skills acquired while working for the franchised broker are transferable (advertising techniques, time management, pricing, etc.).

Since approximately 30% of the listing agents in the sample have worked for both types of brokers, “Listed by Franchise" is still identified when the franchised listing agent variable is included. The estimates in Columns 1 and 2 show that there is a positive “franchise effect" of 3% for waiting an additional three days to locate a buyer. However, this preferred performance from a seller’s perspective is negated by the performance of agents who choose to affiliate with a franchised listing broker. Listing with an agent who has, is, or ever will be affiliated with a franchise results in a quicker sale, however, they sell houses on average for 5.4% less than someone who has never affiliated with a franchise. Combining the coefficients in Rows 1 and 3 implies that controlling for agents who have affiliated with a franchise, listing with a franchised broker leads to a quicker sale of 5.3

[39]Frew and Jud (1986) find that regional franchises generate more revenue than national franchises and have more agents which is consistent with the results in Table 3.6. The largest independent broker in the sample has the largest number of agents, multiple offices that operate in southern Indiana and the Greater Louisville area, and are shown to perform better than small independent brokers and the national franchises.

days at the expense of a 2.4% reduction in sales price. Similar results are found when the base category is small independent brokers. In both specifications it appears that lead generating systems and referral networks give the franchised brokers an edge over independent brokers in terms of locating buyers, however, in both instances the reduction in sales price is too large to make a selling homeowner indifferent between the quicker sale and lower price.

The estimates in Table 3.7 assume that all agents who affiliate with a franchised listing broker are identical. Since agents select into different franchises for different reason, fixed effects for each listing agent who affiliates with a franchised listing broker are included. These results are shown in Table 3.8[40]. The estimates in Columns 1 and 2 show that controlling for the listing agent, franchised brokers perform on par with independent listing brokers and there is no evidence of a franchise effect. While the coefficient on “Listed by Franchise" is approximately 80% smaller than in Table 3.7, it is still precisely estimated. When compared to small independent listing brokers, houses listed with a franchised broker sell for approximately 1.4% more, however, they take just as long as an independent broker to locate a buyer.

It appears that any differences in the time it takes to locate a buyer and the sales price for independent and franchised listing brokers are explained almost entirely by the agents who affiliate with a franchised broker. When assuming all agents who affiliate with a franchise are identical, listing with a franchised broker results in a 3-4% ($5,473-$7,298) increase in sales price compared to a comparable house listed with an independent broker for waiting an additional three days to locate a buyer. When the model allows for heterogeneity among the agents who choose to affiliate with a franchise, listing with a franchised broker results in at most a 1.4% ($2,554) increase in sales price. These estimates differ substantially from the specification that did not control for the type of

[40]The full output is shown in Table A2.7.

agent who listed the property which show houses listed with a franchised brokers being associated with a sale date four days earlier at a discount of 0.3-1.3% ($671-$2,408).

The results above show that after controlling for differences in the types of agents who choose to affiliate with a franchise compared to those who always work for an independent broker, there is a positive return associated with franchise listing brokers. Comparing the results in Table 3.6 to the results in Tables 3.7 and 3.8, it appears that the weaker agents are the ones selecting into the franchised brokerage firms ("Listed by Franchise" is negatively correlated with ever being affiliated with a franchise). Two plausible explanations for this result come to mind. First, a less-skilled agent has the most to gain from the brand recognition, brand loyalty, and advertising campaigns associated with a franchise since these are by nature public goods of which the agent can be a free rider (Mathewson and Winter (1985); Blair and Lafontaine (2010)). For a new and inexperienced agent, breaking into the real estate industry can be tough. In this sample, the average agent lists about 5.5 properties per year and sells 5. At an average selling price of $182,445, assuming the agent sells their own listings 26% of the time, a 6% commission, and a 60/40 split with their broker, the average agent in the sample earns approximately $20,688 in commissions before taxes and any expenses are subtracted[41]. Holding all else constant, if the new agent can receive the benefits of on-the-job training, a nationally recognized brand name, and a lead generating system to jump-start their career, affiliating with a franchise could be the best way to increase their annual commission to a level comparable to what they could have earned working an hourly or salaried position in a different industry.

Another possible explanation is that agents working for franchised listing brokers have a higher discount rate than those who work with independent brokers, and prefer a quick commission to the slightly higher commission they could have earned by waiting a few

[41]The 2007-2011 median income for the study area is $43,60 according to the US Census estimates.

additional days and selling the house closer to list price. A similar explanation is proposed in Levitt and Syverson (2008) as a possible reason for agent-owned properties being on the market longer and selling for more than houses that were not agent-owned. Using the estimates from Tables 3.7 and 3.10, if the listing agent waits the additional 8.3 days to locate a buyer without the reduction in sales price of 5.5%, the expected increase in commission (assuming they sell their own listing 26% of the time and have a 60/40 split with their broker) is $222. As in Levitt and Syverson (2008), the difference in discount rates required to explain the difference is extremely large; the annual interest rate required making the agent indifferent between the quicker commission and a commission $222 higher 8.5 days later is 243%. While a principle-agent problem could exist that encourages the listing agent to advise the homeowner to accept the discount for a quicker sale, it is unlikely that this problem affects franchised and independent agents differently.

Tables 3.9-3.11 allow for heterogeneity across franchises[42]. In Table 3.9, when compared to all independent brokers, Century 21 sells houses three days sooner at a 3% discount, while Keller Williams sells houses almost three weeks quicker and at a premium of 6.5%[43]. When compared to small independent brokers, Coldwell Banker gets a house off the market about 5.5 days sooner without a reduction in sales price, and Keller Williams still sells houses almost 3 weeks sooner, but a premium of 7.4%. When the dummy variable indicating that the listing agent has been affiliated with a franchise is included (Table 3.10), there is a positive “franchise effect" for each franchise, however, the coefficient on the franchise listing agent variable is still negative and significant in both the sales price and days on market regressions. Keller Williams still appears to be the most efficient franchise selling houses nearly three weeks sooner than properties listed with an independent broker at a premium of 5.5%[44]. When the model allows for

[42]The corresponding full output is shown in Tables A2.8-A2.10.

[43]This is very similar to amount above an independent listing broker that Keller Williams lists their houses.

[44]Keller Williams’ small market share could indicate their agents are more selective in the houses they choose to list and sell. If within a census tract, Keller Williams disproportionately sells more expensive houses in more desirable locations, the results presented here would over-state the “franchise effect" associated with

heterogeneity in the agents who affiliate with a franchise (Table 3.11), Century 21 takes about five days longer to locate a buyer, however, there is no premium in sales price for waiting. Houses listed with Coldwell Banker are off the market about a week and a half sooner, but sell for about 1.8% less (the homeowner needs an annual return of 61% to be indifferent between this reduction and waiting an additional week and a half without the reduction). The premium associated with Keller Williams listing brokers fell to 3% compared to all independent brokers and 4.4% when compared to small independent brokers, and they are now selling houses about seven days sooner than an independent broker. Houses listed with RE/MAX are on the market just as long as a house listed with an independent broker, but they receive a 1.2% premium when compared to all independent brokers, and a 2.2% premium when compared to small independent brokers. Even though on average it appears that weaker agents choose to affiliate with a franchise, this does not appear to be the case for Keller Williams and RE/MAX. Keller Williams' focus on building a local brand identity and profit sharing, and RE/MAX's 100% commission structure could be what attracts the stronger agents to these franchises.

3.6.3 Franchised Broker Sales in Areas with More Out-of-State Movers

The OLS results from regressions comparing the performance of franchised and independent brokers in areas with higher concentrations of out-of-state movers are reported in Table 3.12[45]. Baryla and Zumpano (1995) show that by working with a real estate agent, consumers moving to an area in which they are unfamiliar can reduce their transactions cost and reduce the duration of their search. As suggested in Brickley and Dark (1987) and Frew and Jud (1986), each specification here suggests that franchised selling brokers are more likely to find buyers for houses located in areas with a higher

their brand.

[45]The marginal effects from a probit regression are shown in Table A2.14 Columns 3-5. The full output is given in Table A2.11.

percentage of out-of-state movers[46]. The dependent variable is a dummy variable equal to one if the property was sold by a franchised brokerage firm, so the “5 Mi Ft Knox" variable in Column 1 says that houses located within 5 miles of the Ft. Knox military base are 1.4% more likely to be sold by one of the three franchised brokerage firms, however, it is not significant at conventional levels.

Columns 2 and 3 in Table 3.12 include potentially more precise measures, the percentage of out-of-state residents in the census tract where the sold property is located. Column 2 uses the estimate of out-of-state movers from the 2000 Census. Since this question asks about the person’s residence in 1995, it is possible that some people are being labeled out-of-state movers when in fact they moved more recently from a location within the same state. If the data are overstating the number of out-of-state movers at the census tract level, this estimate will be biased upwards. Using this measure, a one standard deviation increase in percentage of out-of-state movers in a census tract, a franchised selling broker is 1.2% more likely to sell a property located in that census tract. While there is no prior estimate of this effect to compare the size of the coefficient, the positive and significant coefficient is consistent with the idea of franchised sales being more prevalent in areas where consumers are less familiar with the local market.

Column 3 uses the estimate of out-of-state movers from the 2010 ACS 5-year estimates and also suggests franchised real estate brokers are more active in areas with larger percentages of out-of-state movers although the effect is much smaller (a one standard deviation increase in out-of-state movers in a census tract, a franchised selling broker is 0.6% more likely to sell a property located in that census tract). Since the estimate of

[46]Lambson et al. (2004) look at the prices out-of-state buyers pay for real estate and find that out-of-state buyers do pay a premium. While the results are not shown, a regression of sales price on the structural characteristics, year-month dummy variables, and the percentage of out of state movers in the census tract in which the house is located shows that the sales price of a house is increasing in the percentage of out-of-state movers in the census tract where the house is located. Using the 2010 estimate of out-of-state movers, a one standard deviation increase in the percentage of out-of-state movers leads to a 5% increase in sales price.

out-of-state movers in column 3 is based on a person's residence 1 year ago, it is less likely to overstate the number of out-of-state movers in a census tract. The smaller coefficient in Column 3 compared to Column 2 is consistent with the idea that the 2000 estimate used in Column 2 is overstating the number of out-of-state movers, and that the coefficient is likely biased upwards. Because the estimate of the percentage of out of state movers is measured at the census tract level, no census tract fixed effects can be included in columns 2 and 3. A shortcoming of not being able to include the census tract fixed effects is that other unobservables such as crime rates, school quality, environmental conditions, and demographics that could be correlated with the number of people who move to a specific area from out of town are not being held constant[47].

There are a few reasons why the results in Table 3.12 should be expected. If the buyer has worked with a particular franchise in the past, they will tend to be more willing to work with them in the future and can be referred to an agent with the same company where they are moving. Even if they are working with an independent broker where they are currently selling a house, that broker could refer them to a franchised broker where they are moving if they are less familiar with the different brokers in the new area and associate a particular franchise with a certain level of quality. It may not be the case that the franchised broker where the person is moving is better at attracting out-of-town buyers because of their local advertising and marketing, but that they are a part of a larger referral network and consumers are brand loyal. Rubin (1978) suggests that firms affiliating with a franchise are buying a trademark that signals a certain level of quality to potential consumers. Since out-of-state movers are unfamiliar with the quality of local real estate brokerage firms they will be more likely to work with a franchised broker if they associate their "brand name" with a certain level of quality[48].

[47] While there are likely unobservables that are correlated with the percentage of out of state movers, the correlation between those unobservables and whether or not the property is sold by a franchised firm is likely weak.

[48] Results that show the probability of listing with a franchised broker in areas where sellers are less familiar with the local market are shown in Table A3.12. The results suggest that franchised listing brokers are

3.7 Conclusions

Home-sellers want a quick sale at a high price. While there are a few houses on the market where the sellers are not really motived to sell but would if the “right" buyer came along, most people with houses for sale are likely doing so because they are either purchasing a new house, building, or relocating. With the exception of a few, sellers are willing to make a tradeoff between the sales price of a house and the length of time it stays on the market. Using 12 years of detailed sales data from an area in Central Kentucky, this paper presented a model of real estate brokerage that incorporated the differences between franchised and independent brokers, and compared the list price, sales price, and days on market for both types of firms taking into account the possible differences in listing agents that choose to affiliate with a franchised broker.

A comparison of the list prices for franchised and independent listings shown in Columns 1 and 2 of Table 3.5 shows that franchised listing brokers lists houses for 1.3% less than a comparable house listed with an independent broker, a result inconsistent with the models prediction. This suggests that franchised brokers may be strategically underpricing houses for a quicker sale and a slightly lower commission. The estimates in Columns 3 and 4 of Table 3.5 show that franchised listing brokers are about 2% less likely to sell their own listing compared to an independent listing broker. The sign is consistent with the model's prediction, but the magnitude is approximately two-fifths as large. Since the model is very stylized and only considers the royalty franchised brokers pay and the different marginal costs of effort for franchised and independent brokers, it is not surprising that the theoretical and empirical estimates diverge.

also more active in areas with a larger proportion of out-of-state movers. However, the coefficients and R^2 are smaller. For example, in the sold by franchised broker regression using the 2010 ACS estimate of the percentage of out-of-state movers, for every one percent increase in the number of out-of-state movers in the census tract, the probability the house is sold by a franchised broker increases by 0.032 percentage points, and the R^2 is .12. In the listed by franchised broker regression, the same increase in the percentage of out-of-state movers leads to a 0.028 percentage point increase in the probability a house is listed with a franchised broker with an R^2 of 0.01.

The results show that most of the difference in the time it takes to locate a buyer and the sales price the listing broker is able to get the homeowner can be attributed to the listing agents who choose to affiliate with each type of firm. In Table 3.6 where no agent characteristics are included, listing with a franchised broker results in a house being sold 3.6 days sooner, but at a discount of 1.3% ($2,408). The required annual return required to make the homeowner indifferent between this tradeoff and waiting an additional 3.6 days without facing the reduction is 131%. When a single dummy variable is included indicating that the listing agent has, is, or ever will be affiliated with a franchised listing broker (Table 3.7), there is a positive “franchise effect" of 3.1% for waiting an additional three days for a buyer to be located. This is equivalent to an annual return of 366%, however, it appears that on average it is the weaker agents who choose to affiliate with a franchise. This is plausible given weaker agents have more to gain by affiliating with a franchise that has a strong brand name with brand loyal customers and a lead generating system. In the most flexible specification (Table 3.8), the model allows for heterogeneity in the listing agents who choose to affiliate with a franchise. There is not enough evidence to say that homeowners are any better or worse off by listing with a franchised broker compared to an independent broker. When the model allows the impact on days on market and sales price to vary by franchise, and by listing agent, there is a positive “franchise effect" associated with Keller Williams and RE/MAX, and it appears that above-average agents are choosing to affiliate with these companies.

An area where franchised brokers differ from independent brokers is in their ability to match buyers and sellers who move from out of state. Table 3.12 shows that franchised brokers are more likely to sell houses in areas with a higher percentage of out-of-state movers. A one standard deviation increase in the percentage of out-of-state movers in the census tract in which the house is located leads to a 0.6-1.2% percentage point increase in the probability that it is sold by a franchised broker. Using the proportion of houses sold

by a franchise in this sample (39%), a 0.6-1.2% point increase implies a 1.5-3.1% increase in the probability that a house is sold by a franchised broker. This could be due to brand loyalty of out-of-state movers or the nationwide referral network that franchised brokers are able to take advantage of. This is consistent with the literature on franchising that says franchises should be more prevalent in areas where the customers are less familiar with the local market.

3.8 Tables and Figures

Table 3.1: Revenues for Owners and Listing Brokers

Revenues for Franchised Listing

	Sold By LB	Sold By DB
Owner	(1-k)P	(1-k) P
Listing Broker	(1-r)kP	$(1-r)\mu$kP

Revenues for Independent Listing

	Sold By LB	Sold By DB
Owner	(1-k)P	(1-k) P
Listing Broker	kP	μkP

"LB"=Listing Broker, "DB"=Different Broker

Table 3.2a: Model Estimates with Equal Marginal Cost of Effort
($c_F = c_I = 100$)

	L_I	S_I	Φ_I	Γ_I	Θ_I	Homeowner Payoff
Independent	2.236	1.764	0.282	0.378	0.66	\$15,502
	L_F	S_F	Φ_F	Γ_F	Θ_F	
Franchised	1.803	1.829	0.224	0.422	0.645	\$15,166

r=.05, μ=.5, k=.06,c_F=100, B=100,000,P_F=50,000, α_F^l=.35, α_F^s=.65
c_I=100, P_I=50,000, α_I^l=.37, α_I^s=.63

Table 3.2b: Model Estimates with Different Marginal Cost of Effort
($c_F = 90$, $c_I = 100$)

	L_I	S_I	Φ_I	Γ_I	Θ_I	Homeowner Payoff
Independent	2.236	1.764	.282	.378	.66	\$15,502
	L_F	S_F	Φ_F	Γ_F	Θ_F	
Franchised	2.016	2.052	.232	.489	.671	\$15,768

r=.05, μ=.5, k=.06,c_F=100, B=100,000,P_F=50,000, α_F^l=.35, α_F^s=.65
c_I=100, P_I=50,000, α_I^l=.37, α_I^s=.63

Table 3.3: Market Shares for the Franchised Firms and Largest Independent Firm in the Sample

Firm[a]	% Listing Agents	% Listings	% Selling Agents	% Solds	% Sold In-house
Franchised					
CENTURY 21	10.79	7.69	10.89	6.97	35.69
COLDWELL BANKER	9.93	8.33	9.79	7.50	36.40
KELLER WILLIAMS	3.55	1.42	4.05	2.18	25.01
RE/MAX	13.97	24.89	14.93	22.31	34.66
Independent					
SEMONIN REALTORS[b]	21.69	14.40	22.08	16.02	41.20

[a] The firm names were cleaned and combined using the method in Yelowitz et al. (2013). The listing and selling agents names were cleaned using a similar method.

[b] Semonin Realtors is a real estate company that is owned by Home Services of America, a Berkshire Hathaway affiliate. They have seven locations and operate in the Greater Louisville, Elizabethtown, and southern Indiana markets.

Table 3.4: Comparison of Transaction and House Characteristics for Listings of Franchised and Independent Firms. Central Kentucky Data, 2000-2011. Independent Sample Size=84,120, Franchised Sample Size=61,731

	Mean		Test Statistic
Variable	Independent	Franchised	Independent-Franchised
Transaction			
List Price (2011 Dollars)[a]	192,878	186,747	7.73
Sold Own Listing	0.366	0.349	7.01
Sold by Franchise	0.251	0.578	-131.49
Sales Price (2011 Dollars)[a]	184,740	179,317	7.31
Days on Market	85.349	83.808	3.5
% Out of State 5 Years Ago	8.866	9.126	-9.19
% Out of State 1 Year Ago	10.513	10.828	-3.04
5 Miles Ft. Knox	0.076	0.118	-26.23
Degree Overpricing[b]	0.005	-0.007	8.8
# of Selling Agents in Listing Firm	126.346	60.651	92.45
House			
Bedrooms	3.231	3.252	-5.09
Full Bathrooms	1.809	1.816	-1.59
Partial Bathrooms	0.368	0.364	1.29
Square Feet of Living Space	1,658	1,647	2.79
Lotsize (Acres)	0.801	0.901	-3.95
Lotsize Missing	0.045	0.046	-1.29
Has $<$ in Lot Dimensions[c]	0.129	0.116	7.2
Has $>$ in Lot Dimensions[c]	0.003	0.004	-1.97
Age (Years)	33.378	32.369	6.58
Age Unknown	0.009	0.012	-4.27
Fireplace	0.474	0.478	-1.5
Basement	0.600	0.600	-0.03
Finished Basement	0.162	0.19	-14.12
Central Air	0.909	0.905	2.77
Brick Exterior	0.339	0.352	-5.02
Vinyl Exterior	0.161	0.176	-7.53
Metal Roof	0.010	0.010	0.06
Composition Roof	0.944	0.932	9.25
Ranch Style	0.447	0.454	-2.78
Modular Style	0.014	0.016	-1.89
Cape Cod Style	0.088	0.078	6.72
Carport	0.057	0.058	-1.24
Garage	0.665	0.641	9.72
One Car Garage	0.167	0.169	-1.04
Multiple Car Garage	0.559	0.567	-2.82
Within 1 Mile Parkway/Interstate	0.484	0.470	5.21
Within 1 Mile Railroad	0.507	0.511	-1.47

[a] List and sales prices were converted to average 2011 dollars using the CPI. N=145,851. Regressions were estimated that excluded houses that sold for less than $10,000 (1,017 observations) and similar results were found. All of the results reported below do not exclude these observations.

[b] Residual from a sales price regression on housing characteristics, time, and location.

[c] The lot dimensions indicated the lot size was less (greater) than the listed size.

Table 3.5: Franchised Real Estate Broker Results from OLS Regressions for List Price and Sale of Own Listing. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(List Price)	(2) ln(List Price)	(3) Sold Own Listing	(4) Sold Own Listing
Listed by Franchise	-0.0128***		-0.0206***	
	(0.00143)		(0.00256)	
Listed by RE/MAX		-0.0158***		-0.0116***
		(0.00171)		(0.00302)
Listed by Coldwell Banker		-0.00494**		-0.0303***
		(0.00245)		(0.00467)
Listed by Century 21		-0.0280***		-0.0452***
		(0.00275)		(0.00476)
Listed by Keller Williams		0.0682***		0.0109
		(0.00532)		(0.00968)
# of Selling Agents in the Listing Firm			0.000173***	0.000175***
			(8.48e-06)	(8.49e-06)
Constant	10.63***	10.63***	0.535***	0.532***
	(0.144)	(0.144)	(0.164)	(0.164)
Observations	145,851	145,851	145,851	145,851
R-squared	0.861	0.861	0.067	0.067
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.6: Regression Results for Comparison of Sales Price and Days On Market for Franchised and Independent Real Estate Brokers. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Franchise	-0.0132***	-3.642***	-0.00368**	-3.621***
	(0.00156)[b]	(0.436)	(0.00172)	(0.478)
Sold by Franchise	0.00186	-0.934**	0.00831***	-1.131**
	(0.00154)	(0.442)	(0.00170)	(0.482)
Listed by Largest Indep.			0.0387***	0.0129
			(0.00208)	(0.634)
Sold by Largest Indep.			0.0263***	-0.721
			(0.00204)	(0.591)
Degree Overpricing[c]		31.23***		31.26***
		(0.857)		(0.860)
Constant	10.56***	150.5***	10.55***	150.4***
	(0.143)	(29.19)	(0.143)	(29.19)
Observations	145,851	145,851	145,851	145,851
R-squared	0.851	0.106	0.852	0.106
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.

[c] Residual from a sales price regression on housing characteristics, time, and location.

*** p<0.01, ** p<0.05, * p<0.1

Table 3.7: Regression Results for Comparison of Sales Price and Days On Market for Franchised and Independent Real Estate Brokers using Franchised Listing Agent Fixed Effects Specification 1. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Franchise	0.0306***	3.020***	0.0396***	3.017***
	(0.00271)[b]	(0.677)	(0.00278)	(0.705)
Sold by Franchise	0.00184	-0.935**	0.00837***	-1.116**
	(0.00154)	(0.442)	(0.00170)	(0.482)
Listing Agent has, is, or will be Affiliated with a Franchise[c]	-0.0545***	-8.305***	-0.0541***	-8.303***
	(0.00266)	(0.672)	(0.00264)	(0.672)
Listed by Largest Indep.			0.0380***	-0.0650
			(0.00208)	(0.634)
Sold by Largest Indep.			0.0266***	-0.670
			(0.00203)	(0.590)
Degree Overpricing[d]		30.62***		30.66***
		(0.860)		(0.862)
Constant	10.58***	153.7***	10.58***	153.6***
	(0.144)	(29.01)	(0.144)	(29.01)
Observations	145,851	145,851	145,851	145,851
R-squared	0.852	0.107	0.852	0.107
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.

[c] This is a dummy variable equal to one if the listing agent has, is, or ever will be affiliated with a franchise, even if the listing agent is currently working for an independent broker. This is done to avoid perfect multicollinearity with "Listed by Franchise." 30% of the listing agents in the sample worked for both types of brokers.

[d] Residual from a sales price regression on housing characteristics, time, and location.

*** p<0.01, ** p<0.05, * p<0.1

Table 3.8: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers using Franchised Listing Agent Fixed Effects Specification 2. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Franchise	0.00575	-1.767	0.0142***	-1.656
	(0.00367)[b]	(1.145)	(0.00371)	(1.165)
Sold by Franchise	0.00140	-1.242***	0.00593***	-1.522***
	(0.00147)	(0.443)	(0.00162)	(0.484)
Listed by Largest Indep.			0.0338***	0.363
			(0.00215)	(0.680)
Sold by Largest Indep.			0.0183***	-0.995*
			(0.00196)	(0.589)
Degree Overpricing[c]		24.50***		24.51***
		(0.915)		(0.916)
Constant	10.59***	144.6***	10.59***	144.5***
	(0.123)	(30.07)	(0.123)	(30.06)
Observations	145,851	145,851	145,851	145,851
R-squared	0.869	0.144	0.869	0.144
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	Yes	Yes	Yes	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.

[c] Residual from a sales price regression on housing characteristics, time, and location.

*** p<0.01, ** p<0.05, * p<0.1

Table 3.9: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers. Separate Firm Intercepts. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Century 21	-0.0306***	-3.041***	-0.0211***	-3.011***
	(0.00300)[b]	(0.829)	(0.00308)	(0.852)
Sold by Century 21	1.20e-06	-0.755	0.00603**	-0.943
	(0.00292)	(0.865)	(0.00300)	(0.886)
Listed by Coldwell Banker	-0.00664**	-5.516***	0.00208	-5.477***
	(0.00273)	(0.799)	(0.00281)	(0.823)
Sold by Coldwell Banker	-0.00117	-1.399*	0.00504*	-1.589*
	(0.00287)	(0.827)	(0.00295)	(0.849)
Listed by Keller Williams	0.0654***	-19.07***	0.0744***	-19.04***
	(0.00585)	(1.472)	(0.00589)	(1.482)
Sold by Keller Williams	0.0392***	-0.803	0.0459***	-0.996
	(0.00548)	(1.414)	(0.00552)	(1.426)
Listed by RE/MAX	-0.0143***	-2.197***	-0.00458**	-2.167***
	(0.00185)	(0.508)	(0.00199)	(0.544)
Sold by RE/MAX	-0.000196	-0.902*	0.00641***	-1.099*
	(0.00181)	(0.532)	(0.00195)	(0.567)
Listed by Largest Indep.			0.0386***	0.0553
			(0.00208)	(0.634)
Sold by Largest Indep.			0.0262***	-0.707
			(0.00203)	(0.591)
Degree Overpricing[c]		31.52***		31.55***
		(0.859)		(0.862)
Constant	10.56***	149.5***	10.56***	149.5***
	(0.143)	(29.25)	(0.143)	(29.25)
Observations	145,851	145,851	145,851	145,851
R-squared	0.852	0.107	0.852	0.107
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.

[c] Residual from a sales price regression on housing characteristics, time, and location.

*** p<0.01, ** p<0.05, * p<0.1

Table 3.10: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers using Franchised Listing Agent Fixed Effects Specification 1. Separate Firm Intercepts. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Century 21	0.0130***	3.648***	0.0220***	3.654***
	(0.00373)[b]	(0.976)	(0.00378)	(0.996)
Sold by Century 21	0.000338	-0.703	0.00644**	-0.875
	(0.00291)	(0.864)	(0.00299)	(0.886)
Listed by Coldwell Banker	0.0363***	1.091	0.0445***	1.107
	(0.00348)	(0.957)	(0.00353)	(0.978)
Sold by Coldwell Banker	-0.00131	-1.419*	0.00499*	-1.594*
	(0.00286)	(0.826)	(0.00295)	(0.848)
Listed by Keller Williams	0.109***	-12.38***	0.117***	-12.38***
	(0.00626)	(1.559)	(0.00629)	(1.569)
Sold by Keller Williams	0.0389***	-0.834	0.0457***	-1.012
	(0.00547)	(1.413)	(0.00551)	(1.426)
Listed by RE/MAX	0.0294***	4.529***	0.0387***	4.535***
	(0.00289)	(0.722)	(0.00297)	(0.749)
Sold by RE/MAX	-0.000238	-0.908*	0.00645***	-1.090*
	(0.00181)	(0.532)	(0.00195)	(0.566)
Listing Agent has, is, or will be Affiliated with a Franchise[c]	-0.0542***	-8.349***	-0.0538***	-8.346***
	(0.00266)	(0.672)	(0.00264)	(0.672)
Listed by Largest Indep.			0.0380***	-0.0222
			(0.00208)	(0.633)
Sold by Largest Indep.			0.0265***	-0.656
			(0.00203)	(0.590)
Degree Overpricing[d]		30.91***		30.95***
		(0.862)		(0.864)
Constant	10.58***	152.7***	10.58***	152.7***
	(0.144)	(29.08)	(0.144)	(29.08)
Observations	145,851	145,851	145,851	145,851
R-squared	0.852	0.107	0.853	0.107
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.

[c] This is a dummy variable equal to one if the listing agent has, is, or ever will be affiliated with a franchise, even if the listing agent is currently working for an independent broker. This is done to avoid perfect multicollinearity with “Listed by Franchise." 30% of the listing agents in the sample worked for both types of brokers.

[d] Residual from a sales price regression on housing characteristics, time, and location.

*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers using Franchised Listing Agent Fixed Effects Specification 2. Separate Firm Intercepts. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Century 21	0.000471	5.053**	0.00588	5.164***
	(0.00713)[b]	(1.993)	(0.00714)	(2.000)
Sold by Century 21	-0.00131	-0.970	0.00294	-1.238
	(0.00275)	(0.866)	(0.00282)	(0.888)
Listed by Coldwell Banker	-0.0186**	-11.16***	-0.0137*	-11.04***
	(0.00757)	(3.077)	(0.00757)	(3.082)
Sold by Coldwell Banker	-0.00381	-2.275***	0.000678	-2.545***
	(0.00272)	(0.828)	(0.00280)	(0.851)
Listed by Keller Williams	0.0296***	-6.729***	0.0437***	-6.627***
	(0.00811)	(2.281)	(0.00816)	(2.292)
Sold by Keller Williams	0.0316***	-1.375	0.0365***	-1.645
	(0.00523)	(1.410)	(0.00527)	(1.422)
Listed by RE/MAX	0.0119***	-0.0445	0.0222***	0.0501
	(0.00459)	(1.269)	(0.00462)	(1.287)
Sold by RE/MAX	0.000758	-0.970*	0.00544***	-1.251**
	(0.00173)	(0.531)	(0.00186)	(0.566)
Listed by Largest Indep.			0.0345***	0.341
			(0.00215)	(0.680)
Sold by Largest Indep.			0.0184***	-0.980*
			(0.00196)	(0.589)
Degree Overpricing		24.48***		24.49***
		(0.915)		(0.917)
Constant	10.59***	144.8***	10.59***	144.7***
	(0.124)	(30.02)	(0.123)	(30.02)
Observations	145,851	145,851	145,851	145,851
R-squared	0.869	0.144	0.869	0.144
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	Yes	Yes	Yes	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.

[c] Residual from a sales price regression on housing characteristics, time, and location.

*** p<0.01, ** p<0.05, * p<0.1

Table 3.12: Regression Results For Comparison of Out-of-State Movers for Franchised and Independent Real Estate Brokers. Central Kentucky Data, 2000-2011

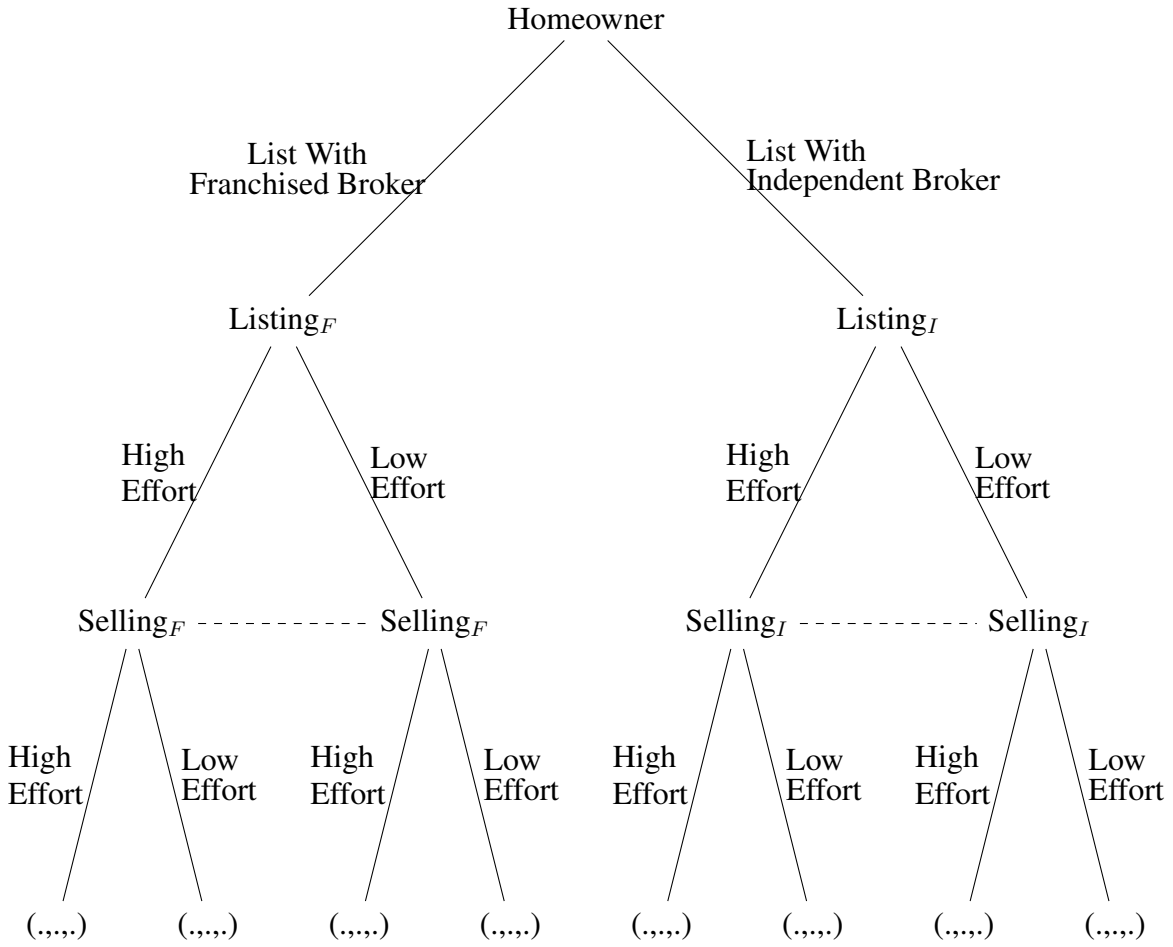
VARIABLES[a]	(1) Sold by Franchise	(2) Sold by Franchise	(3) Sold by Franchise
Listed by Franchise	0.308***	0.322***	0.322***
	(0.00256)[a]	(0.00250)	(0.00250)
5 Miles Ft. Knox	0.0138		
	(0.0110)		
% Out of State 5 Years Ago		0.00226***	
		(0.000265)	
% Out of State 1 Year Ago[c]			0.000315***
			(6.47e-05)
Constant	-0.121	0.184***	0.193***
	(0.0968)	(0.0235)	(0.0236)
Observations	145,851	145,851	145,851
R-squared	0.128	0.116	0.116
Year-Month Dummies	Yes	Yes	Yes
Tract Fixed Effects	Yes	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road.

[b] Robust Standard Errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

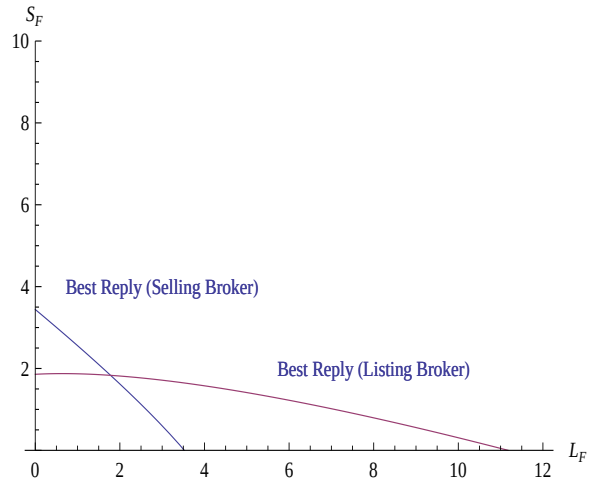
[c] There were 18 observations where this variable was missing. These observations were set to zero, and a dummy variable equal to one was included indicating there was a missing value.
*** p<0.01, ** p<0.05, * p<0.1

Figure 3.1: Game Played by Listing Brokers, Selling Brokers, and the Homeowner



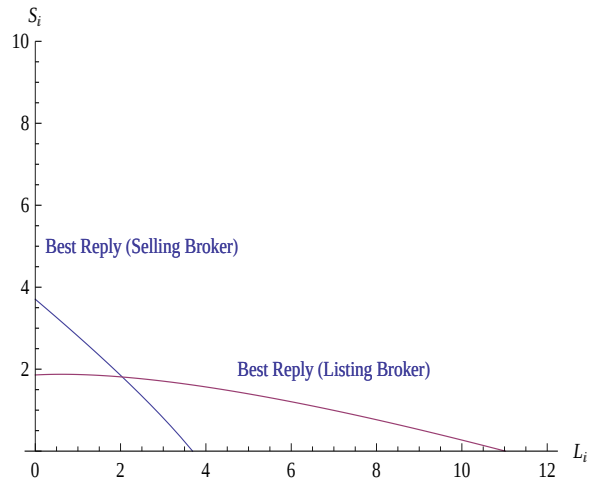
In the game being played listing and selling brokers can choose an effort level in the interval [0,$+\infty$). To simplify the drawing of the game tree, it is assumed they only choose between high and low levels of effort.

Figure 3.2: Best Reply Functions for Franchised Listings (1 Selling Broker)



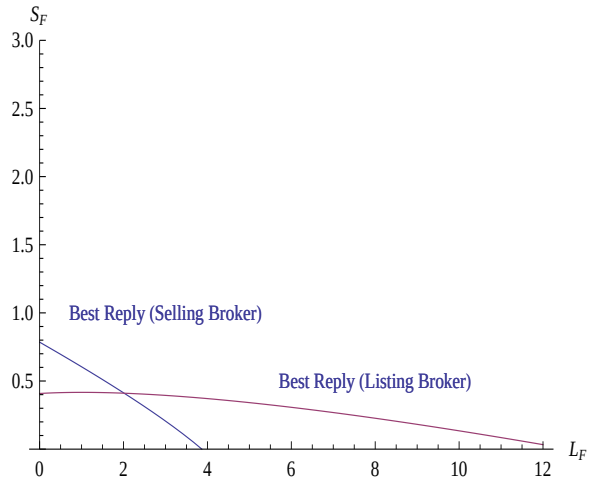
r=.05, μ=.5, k=.06,c_F=100, B=100,000,P_F=50,000, α_F^l=.52, α_F^s=.48
L*=1.803, S*=1.829

Figure 3.3: Best Reply Functions for Independent Listings (1 Selling Broker)



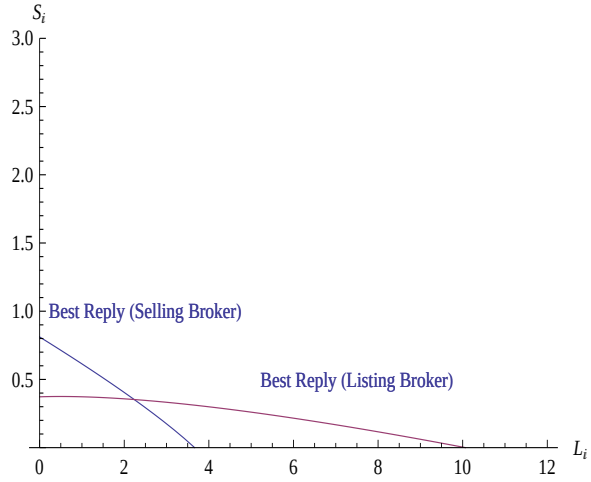
μ=.5, k=.06,c_I=100, B=100,000,P_I=50,000, α_I^l=.45, α_F^s=.55
L*=2.236, S*=1.764

Figure 3.4: Best Reply Functions for Franchised Listings (5 Selling Brokers)



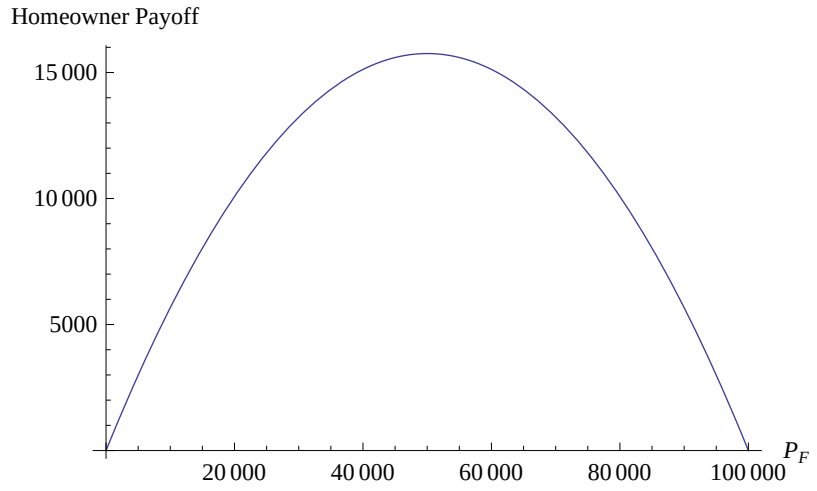
r=.05, μ=.5, k=.06,c_F=100, B=100,000,P_F=50,000, α_F^l=.52, α_F^s=.48
L*=1.803, S*=.366

Figure 3.5: Best Reply Functions for Independent Listings (5 Selling Brokers)



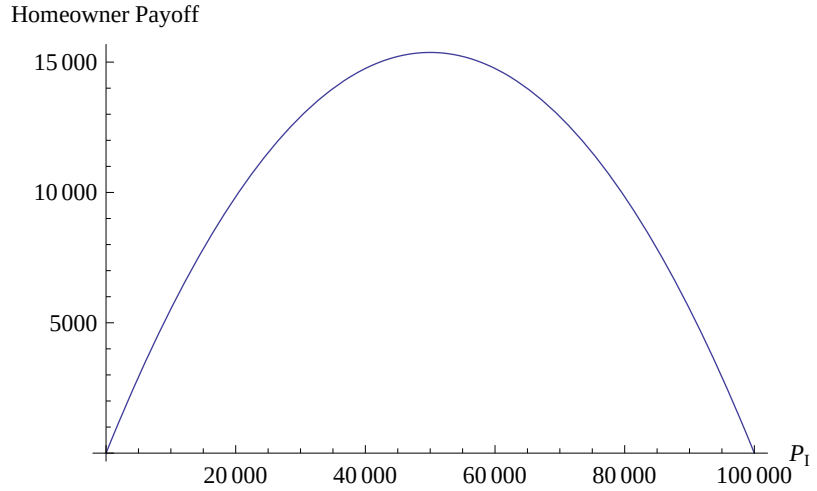
μ=.5, k=.06,c_I=100, B=100,000,P_I=50,000, α_I^l=.45, α_F^s=.55
L*=.2.236, S*=.353

Figure 3.6: Expected Revenue for the Homeowner (Franchised Listing)



μ=.5, k=.06,c_I=100, B=100,000, α_F^l=.35, α_F^s=.65, r=.05

Figure 3.7: Expected Revenue for the Homeowner (Independent Listing)



r=.05, μ=.5, k=.06,c_F=100, B=100,000, α_I^l=.37, α_I^s=.63

4 Conclusion

This dissertation has sought to contribute to the body of knowledge that uses information revealed in housing markets to value non-market goods and the value associated with firms that choose franchising as an organizational form. Rosen (1974) shows that the sales price of a differentiated good can be expressed as a function of its individual attributes. With housing, these attributes can be divided into three categories: structural, neighborhood, and environmental. In equilibrium, the implicit price of each of these attributes, given by the partial derivative of the hedonic price function with respect to each attribute, is an estimate of the willingness to pay for a small increase in that attribute. Chapter 2 uses this basic framework to estimate the disamenity value associated with communication antennas, and exploits econometric advances that have been made over the last 40 years. Chapter 3 uses this framework to carefully control for differences in the types of houses and for markets franchised and independent firms are active in to determine the value associated with franchised real estate brokerage firms.

Chapter 2 uses the most recent developments in the hedonic property value model and quasi-experimental literature to estimate the disamenity value associated with communication antennas. Kuminoff et al. (2010) show that including spatial fixed effects in the hedonic price function will reduce the bias caused by spatially correlated time-invariant unobservables. This type of bias is the greatest concern in this study. Holding all else constant, the owner of a communication antenna will locate it in an area that will cost the least. If the endogenous antenna location is not controlled for, the cross-section estimates of willingness to pay to avoid living near these antennas will be biased. Kuminoff et al. (2010) also recommend using a repeat sales model or a generalized difference-in-difference specification that eliminates the bias caused by time-invariant spatially correlated unobservables if panel data is available. The willingness to pay to avoid living near a communication antennas is estimated and

compared using each of these methods.

The results in Chapter 2 show that time-invariant spatially correlated unobservables are a concern and bias the cross-sectional estimates of the reduction in sales price caused by nearby communication antennas. In each of the cross-section specifications that do not included spatial fixed effects, the estimates of willingness to pay all show that houses near communication antennas sell for more (not less!) than similar houses not located near an antenna. Once spatial fixed effects are included that control for time-invariant unobservables that are correlated with distance to an antenna, each measure of proximity to an antenna indicates that communication antennas are a disamenity and that houses near communication antennas sell for less than a similar house located further away from an antenna. Further evidence of the correlation between the unobservables and proximity is found when the most precise fixed effects were included. When census block-group fixed effects were used that are more precise than census tract fixed effects, the estimated reduction in sales price caused by a communication antenna becomes smaller and is estimated more precisely in each of the cross-section specifications. This reinforces the importance of the carefully controlling for spatial correlated unobservables that are correlated with proximity to a localized disamentiy.

The results show also that the estimates are robust to functional form and that the proximity measures used are capturing the visual disamenity associated with communication antennas. When the quadratic specification is used, the sales price of a house is increasing at a rate of 0.75% at a distance of 2,500 feet from an antenna, and at a rate of 0.60% at 2,500 feet using the inverse of distance. At an average sales price of $183,619, this amounts to a difference of $275. When the sample is reduced to only include the large tower-type antenna structures, the quadratic specification shows that the sales price of a house is increasing at a rate of 0.92% at a distance of 2,500 feet compared to 0.75% when all antennas was used, a difference of $332. When all of the antennas are

included, no sales price effect is found beyond 15,540 feet (2.94 miles) compared to a distance of 16,269 feet (3.08 miles) when the sample included only tower-type structures. This provides additional confidence that the spatial fixed effects are absorbing the effect of spatially correlated unobservables and that the distance measures are capturing the visual disamenity associated with communication antennas.

The results in Chapter 2 confirm a hypothesis made by Mastromonaco (2011). His argument suggests that estimating the effect of communication antennas on property values using distance to the nearest antenna is likely biased due to the presence of multiple nearby antennas. Results from the two cross-section specifications that measure proximity using either a dummy variable equal to one if an antenna is located within a specified radius or by counting the number of antennas within the same radius are consistent with his hypothesis. These results show that a house located within 600 feet of an antenna sells for 5.7% ($10,466) less than a similar house more than 4,500 feet away from its nearest antenna. Using the number of antennas within a specified radius shows that adding an additional antenna within 600 feet of a house leads to a reduction in sales price of 3.1% ($5,692). Since the presence of an additional antenna leads to an even further reduction in sales price, estimates of the disamenity value of an antenna that only consider distance to the nearest antenna are likely biased upwards. This result has implications for the valuation of numerous types of localized (dis)amenities in which a house could be affected by multiple sites.

When the estimates from the repeat sales model are compared to the estimates from the preferred cross section specification, the results show that the omitted spatial characteristics that are correlated with proximity to a communication are time invariant, and are being captured by the census block group fixed effects. The repeat sales method eliminates any bias caused by time-invariant unobservables and provides results very similar to the cross sectional estimates that include census block group fixed effects and

uses a continuous measure of distance along with the number of nearby antennas. Using the continuous measure of distance, the sales price of a house increasing at a rate of 0.34% at a distance of 1,000 feet from an antenna, and the repeat sales estimates show that for every 1,000 foot change in distance to the nearest antenna, the sales price increases by 0.39%. Using the average sales price of $183,619, this amounts to a difference of $92. This is consistent with the findings in Kuminoff et al. (2010) and reinforces that importance of including precise spatial fixed effects to control for time-invariant spatially correlated unobservables when panel data is not available.

Estimation of the difference-in-differences specification recommended by Kuminoff et al. (2010) highlights a serious shortcoming of that that technique when houses are affected by multiple sites. Since the difference-in-differences specification takes differences over time for the treatment and control groups, the results should be similar to the estimates from the repeat sales specification. The results from a difference-in-differences specification that includes census tract fixed effects to capture any effect of time-invariant spatially correlated unobservables, and interactions between time and housing characteristics to allow the shape of the hedonic price function to change over time, suggest that the sales price of a house within 2,000 feet of an antenna at the time of sale is no different than the sales price of a similar house more than 2,000 feet away from the nearest antenna. The shortcoming of this technique is illustrated by looking at the method used to define the treatment and control groups proposed by Linden and Rockoff (2008). Using this technique, relationship between the sales price of a house and distance to the nearest standing antenna is compared to the relationship between the sale price and distance to the nearest site where an antenna will be constructed. When houses are affected by the presence of multiple antennas, distance to the nearest site where an antenna will be located will capture the effect of a standing antenna just beyond that site. This complication makes defining the treatment and control groups very difficult. While the

difference-in-differences specification has become increasing popular in the recent literature, the nature of the disamenity evaluated here does not appear meet the criteria necessary to successfully implement this quasi-experimental technique.

The best estimate of reduction in sales price cause by communication antennas shows that the sales price of a house is increasing at a rate of about 0.34% ($624) at a distance of 1,000 feet from the nearest antenna. This suggests that a house within 1,000 feet of the nearest antenna when it is sold will sell for 1.01% ($1,884) less than a similar house that is 4,500 feet from the nearest antenna. Compare this to the results that do not include spatial fixed effects to capture the effect of time-invariant spatially correlated unobservables. These estimates show that the sales price of a house is decreasing at a rate of 0.40% ($734) at a distance of 1,000 feet. This suggests that a house that is within 1,000 feet of the nearest antenna will sell for 1.1% ($2,020) more than a similar house that is 4,500 feet from the nearest antenna. This clearly demonstrates how important it is to include precise spatial fixed effects to capture the effect of time invariant spatially correlated unobservables.

When the sample is restricted to include only tower-type antenna structures, the results show that a house 1,000 feet away from the nearest antenna will sell for 1.33% ($2,482) less than a similar house that is 4,500 feet away. In this sample, there are 2,313 houses within 1,000 feet of a tower-type structure. If for each of these houses the nearest tower-type structure was moved to a distance of 4,500 feet, there would be an aggregate increase in sales price would be equal to $5.74 million. This value should be compared to the cost of camouflaging or disguising communication antennas near residential properties to mitigate the effect they have on property values.

Chapter 3 uses the same housing data that were used to estimate the disamenity value associated with communications to compare the performance of franchised and

independent real estate brokers. The data contain information about the listing and selling firms and agents for each house that sold during the 12 year period the data covered. The data allow for a comparison of franchised and independent real estate brokerage firms while considering the different types of agents who work for each type of firm. Although several papers have made comparisons between franchised and independent real estate brokerage firms, this study is the first to do so using sales data. Franchised real estate brokers have access to a nationally recognized brand name, referral networks, and lead generating systems that independent brokers are not able to take advantage of. These benefits could give franchised brokers an edge over independent brokers that allow them to more efficiently match buyers and sellers, but could also give weaker and less experienced agents an incentive to affiliate with a franchise to boost their reputation as they work to establish themselves in the real estate business.

A theoretical model of real estate brokerage is developed that accounts for the royalty fees franchised real estate brokers must pay the franchisor as well as the reduced marginal cost of effort for franchised real estate brokers that results from having a highly recognizable brand name, referral networks, and lead generating systems. The model shows that if franchised and independent real estate brokers have the same marginal cost of effort, the royalty that the franchised brokers must pay acts as a tax on their effort and their effort is reduced to a point where the homeowner is better off listing with an independent broker. When the marginal cost of effort for a franchised broker is allowed to be lower than the marginal cost of effort for independent brokers because of the benefits franchised brokers are able to take advantage of, their effort levels increase to a point where a homeowner is better off listing their house with a franchised real estate broker.

The theoretical model provides two testable hypotheses. First, it predicts that houses listed with franchised and independent real estate brokers will have the same list price. A test of this hypothesis shows that the list price differs between franchised and independent

brokers and suggests that franchised listing brokers may be strategically underpricing houses in order to obtain a slightly quicker sale. The second prediction is that franchised real estate brokers will sell their own listings less often than an independent broker. This result is due to the fact that the on average independent real estate brokers have a larger number of selling agents working to locate buyers for their listings. The data confirm that franchised brokers sell their own listings less often than independent brokers. However, the empirical estimate of the percentage of listings that are sold “in house" is approximately two-fifths as large as the prediction made by the theoretical model. Since the model is very stylized and only considers the royalty franchised brokers pay and the different marginal costs of effort for franchised and independent brokers, it is not surprising that the theoretical and empirical estimates diverge for list prices and the probability of selling a listing “in house."

The performance of franchised and independent real estate brokers were compared using a method similar to the one used in Levitt and Syverson (2008) that compared the sales price and how long it takes to locate a buyer for listings that are agent owned compared to listings that are not owned by the listing agent. In the models that did not control for the types of agents that choose to work for a franchised or independent broker, the estimates show that houses listed with a franchised broker are sold 3.6 days sooner, but at a discount of 1.3% ($2,408) compared to a comparable house listed with an independent broker. Even though some homeowners will be willing to take a slightly lower sales price to get their house off the market sooner, the tradeoff shown in this specification is one does not lead to the homeowners being made better off. The required annual return required to make the homeowner indifferent between this tradeoff and waiting an additional 3.6 days without facing the reduction is 131%.

As discussed above, weaker and less experienced agents may choose to affiliate with a franchised real estate firm to take advantage of a nationally recognized brand name,

referral networks, training programs, and lead generating systems. The detailed sales data used identify the listing and selling agents for each transaction allowing for a test of this hypothesis. In a specification that assumes all agents who have, are, or ever will affiliate with a franchised listing broker are franchise agents, there is a positive “franchise effect" of a 3.1% increase in sales price for waiting an additional three days for a buyer to be located. This is equivalent to an annual return of 366%. However, the negative coefficient on the franchised listing agent dummy variable indicates that on average the weaker agents who choose to affiliate with a franchise. In the most flexible specification that allows for heterogeneity in the types of agents that affiliate with a real estate franchise there is not enough evidence to say that homeowners are any better or worse off by listing with a franchised broker compared to an independent broker. Using a similar specification that allows for heterogeneity in the agents who have, are, or will be affiliated with a franchise and heterogeneity across franchises, there is a positive “franchise effect" associated with Keller Williams and RE/MAX, and it appears that above-average agents are choosing to affiliate with these companies.

An area where franchised brokers differ from independent brokers is in their ability to match buyers and sellers who move from out of state. The results show that franchised brokers are more likely to sell houses in areas with a higher percentage of out-of-state movers. A one standard deviation increase in the percentage of out-of-state movers in the census tract in which the house is located leads to a 0.60-1.2% increase in the probability that it is sold by a franchised broker. This could be due to brand loyalty of out-of-state movers or the nationwide referral network that franchised brokers are able to take advantage of. This is consistent with the literature on franchising that says franchises should be more prevalent in areas where the customers are less familiar with the local market.

In summary, this dissertation uses information that was revealed in housing markets to

estimate the disamenity value associated with communication antennas and the value of franchised real estate brokerage firms. Both essays benefit from detailed sales data that contain precise location information for each property and characteristics of the selling and buying process. The richer data enables estimation that overcomes econometric issues that limited previous studies.

There are a few areas in which future work should focus. First, since there are a lot of houses in the dataset that were affected by multiple communication antennas, the Linden and Rockoff (2008) method for defining treatment and control groups cannot be used effectively. More work needs to be focused on accurately defining treatment and control groups when houses are likely affected by the presence of multiple sites that are perceived as localized (dis)amenities so that the difference-in-differences specification recommended by Kuminoff et al. (2010) can be estimated with confidence.

Second, communication antennas that were camouflaged by already standing structures such as clocks or church steeples were not identified in this dataset. The data allowed for the estimation of specifications that only included the large tower-type structures, and, as was expected, the bigger and more visually disruptive structures had a larger effect on sales price and had an effect further away. If the camouflaged antennas can be identified and are shown to have a smaller effect than when all antennas are included, this would provide even more evidence that the proximity measures are capturing the visual disamenity associated with communication antennas.

Finally, more work needs to be done looking at the performance of the agents who only affiliate with a franchised broker, who affiliate with a franchised broker and then transfer to an independent broker, and who begin with an independent broker and then transfer to a franchised broker. In this study, agents who fit into any of these three categories were considered to have been associated with a franchise. There are reasons to believe that

agents who affiliate with a franchised real estate broker are different from agents who do not, and the dynamics of how agents move between the different types of firms needs to be investigated. By doing so, a more accurate test of the hypotheses that weaker and less experienced agents have the most to gain from affiliating with a franchise can be performed.

A Appendix

A.1 Chapter 2 Appendix

Table A1.1: Summary Statistics for the Communication Towers Proximity Measures. Central Kentucky Data, 200-2011. N=142,164.

Continuous	Mean	Std. Dev.	Min	Max
Distance to Closest Standing Tower When Sold (feet)[a]	6,353	4,800	59	51,663

Equal to 1 if Within	Share	Number
TowerDistance0to300	0.001	93
TowerDistance300to600	0.004	586
TowerDistance600to900	0.008	1,128
TowerDistance900to1200	0.013	1,879
TowerDistance1200to1500	0.02	2,832
TowerDistance1500to1800	0.024	3,457
TowerDistance1800to2100	0.028	3,934
TowerDistance2100to2400	0.034	4,886
TowerDistance2400to2700	0.036	5,187
TowerDistance2700to3000	0.040	5,670
TowerDistance3000to3300	0.042	5,959
TowerDistance3300to3600	0.042	6,033
TowerDistance3600to3900	0.046	6,528
TowerDistance3900to4200	0.047	6,659
TowerDistance4200to4500	0.044	6,239

Number Within	# Equal to 1	# Equal to 2	# Equal to 3
TowerCount0to300	93	0	0
TowerCount300to600	574	13	0
TowerCount600to900	1,156	10	0
TowerCount900to1200	1,883	24	0
TowerCount1200to1500	2,897	38	0
TowerCount1500to1800	3,559	54	0
TowerCount1800to2100	4,224	91	0
TowerCount2100to2400	5,248	153	1
TowerCount2400to2700	5,903	222	2
TowerCount2700to3000	6,851	271	1
TowerCount3000to3300	7,674	319	9
TowerCount3300to3600	8,043	351	14
TowerCount3600to3900	9,173	519	44
TowerCount3900to4200	10,381	586	24
TowerCount4200to4500	10,694	652	49

[a] Distance in thousands of feet is used in the analysis that follows.

Table A1.2: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values using a Continuous Measure of Distance. Central Kentucky Data, 2000-2011. All Variables.

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance to any Antenna	-0.00922***	-0.0113***	0.0104***	0.00892***
	(0.000624)	(0.000610)	(0.00195)	(0.00176)
Distance^2 to any Antenna	0.000162***	0.000182***	-0.000324***	-0.000287***
	(2.34e-05)	(2.28e-05)	(6.18e-05)	(5.81e-05)
Bedrooms	-0.00280	-0.00508***	0.0205***	0.0227***
	(0.00188)	(0.00184)	(0.00388)	(0.00286)
Full Bathrooms	0.110***	0.128***	0.0923***	0.0895***
	(0.00245)	(0.00241)	(0.00340)	(0.00266)
Partial Bathrooms	0.0623***	0.0722***	0.0485***	0.0460***
	(0.00262)	(0.00256)	(0.00390)	(0.00299)
Square Feet of Living Space	0.000562***	0.000571***	0.000414***	0.000401***
	(6.20e-06)	(6.06e-06)	(1.24e-05)	(1.03e-05)
Square Feet^2	-3.24e-08***	-3.47e-08***	-2.10e-08***	-2.14e-08***
	(1.02e-09)	(9.96e-10)	(2.47e-09)	(1.95e-09)
Lotsize (Acres)	0.0152***	0.0152***	0.0201***	0.0202***
	(0.000397)	(0.000388)	(0.00136)	(0.00126)
Lotsize^2	-4.05e-05***	-4.06e-05***	-5.84e-05***	-5.84e-05***
	(1.91e-06)	(1.86e-06)	(8.78e-06)	(8.77e-06)
Lotsize Missing	0.0560***	0.0143***	-0.00999**	-0.00843**
	(0.00510)	(0.00503)	(0.00439)	(0.00390)
Has $<$ in Lot Dimensions	0.0232***	-0.00626*	-0.0219***	-0.0210***
	(0.00325)	(0.00320)	(0.00356)	(0.00287)
Has $>$ in Lot Dimensions	0.0347*	0.0172	0.00840	0.00454
	(0.0183)	(0.0178)	(0.0124)	(0.0114)
Age (Years)	-0.00279***	-0.00221***	-0.00630***	-0.00692***
	(0.000118)	(0.000115)	(0.000397)	(0.000280)
Age^2	-2.03e-05***	-2.22e-05***	1.79e-05***	2.27e-05***
	(1.10e-06)	(1.08e-06)	(4.47e-06)	(2.83e-06)
Age Unknown	-0.157***	-0.159***	-0.133***	-0.126***
	(0.0106)	(0.0103)	(0.0210)	(0.0174)

Table A1.2 (continued)

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Fireplace	0.138***	0.126***	0.0497***	0.0495***
	(0.00260)	(0.00255)	(0.00396)	(0.00300)
Basement	0.164***	0.166***	0.151***	0.142***
	(0.00261)	(0.00255)	(0.00439)	(0.00346)
Finished Basement	0.0397***	0.0257***	0.0321***	0.0326***
	(0.00322)	(0.00320)	(0.00445)	(0.00310)
Central Air	0.396***	0.381***	0.259***	0.251***
	(0.00390)	(0.00381)	(0.00929)	(0.00681)
Brick Exterior	0.0602***	0.0488***	0.0404***	0.0352***
	(0.00243)	(0.00238)	(0.00340)	(0.00267)
Vinyl Exterior	-0.0776***	-0.0747***	-0.0180***	-0.0113**
	(0.00319)	(0.00312)	(0.00572)	(0.00489)
Metal Roof	-0.0659***	-0.0235**	-0.0150	-0.0121
	(0.0119)	(0.0117)	(0.0164)	(0.0155)
Composition Roof	-0.0320***	-0.000818	0.0153**	0.0175***
	(0.00491)	(0.00504)	(0.00684)	(0.00557)
Ranch Style	0.0723***	0.0910***	0.0616***	0.0559***
	(0.00267)	(0.00270)	(0.00397)	(0.00317)
Modular Style	-0.504***	-0.466***	-0.477***	-0.480***
	(0.00980)	(0.00961)	(0.0147)	(0.0148)
Cape Cod Style	0.0974***	0.108***	0.0474***	0.0407***
	(0.00408)	(0.00405)	(0.00569)	(0.00439)
Carport	0.0455***	0.0481***	0.0136**	0.00954**
	(0.00514)	(0.00502)	(0.00530)	(0.00454)
Garage	0.0863***	0.0967***	0.00517	0.00433
	(0.00331)	(0.00324)	(0.00557)	(0.00461)
One Car Garage	0.119***	0.110***	0.0926***	0.0877***
	(0.00423)	(0.00413)	(0.00595)	(0.00529)
Multiple Car Garage	0.127***	0.124***	0.144***	0.140***
	(0.00392)	(0.00383)	(0.00657)	(0.00544)
Within 1 Mile Parkway/Interstate	-0.0101***	-0.0192***	-0.0262***	-0.0179**
	(0.00238)	(0.00233)	(0.00976)	(0.00708)
Within 1 Mile Railroad	-0.0861***	-0.0917***	-0.0134	-0.0242***
	(0.00230)	(0.00224)	(0.00917)	(0.00681)
Within 1 Mile Ft. Knox	-0.209***	-0.208***	-0.0765**	-0.0572*
	(0.00926)	(0.00904)	(0.0344)	(0.0322)
Constant	10.37***	10.38***	10.50***	10.23***
	(0.0104)	(0.0204)	(0.0315)	(0.0200)
Observations	142,161	142,161	142,161	142,161
R-squared	0.703	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

Table A1.3: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values using the Inverse of Distance to the Nearest Antenna. Central Kentucky Data, 2000-2011. All Variables.

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Inverse Distance to Any Antenna	0.0805***	0.0902***	-0.0358***	-0.0284***
	(0.00372)	(0.00364)	(0.00887)	(0.00755)
Bedrooms	-0.00160	-0.00354*	0.0202***	0.0226***
	(0.00188)	(0.00184)	(0.00388)	(0.00286)
Full Bathrooms	0.111***	0.128***	0.0927***	0.0896***
	(0.00245)	(0.00241)	(0.00340)	(0.00267)
Partial Bathrooms	0.0647***	0.0749***	0.0486***	0.0461***
	(0.00261)	(0.00256)	(0.00389)	(0.00300)
Square Feet of Living Space	0.000558***	0.000566***	0.000415***	0.000401***
	(6.20e-06)	(6.06e-06)	(1.25e-05)	(1.04e-05)
Square Feet^2	-3.20e-08***	-3.41e-08***	-2.11e-08***	-2.14e-08***
	(1.02e-09)	(9.96e-10)	(2.51e-09)	(1.96e-09)
Lotsize (Acres)	0.0142***	0.0138***	0.0202***	0.0203***
	(0.000391)	(0.000382)	(0.00137)	(0.00126)
Lotsize^2	-3.70e-05***	-3.59e-05***	-5.90e-05***	-5.88e-05***
	(1.89e-06)	(1.85e-06)	(8.90e-06)	(8.84e-06)
Lotsize Missing	0.0573***	0.0171***	-0.0103**	-0.00829**
	(0.00509)	(0.00504)	(0.00437)	(0.00389)
Has $<$ in Lot Dimensions	0.0264***	-0.00144	-0.0221***	-0.0211***
	(0.00324)	(0.00320)	(0.00359)	(0.00288)
Has $>$ in Lot Dimensions	0.0363**	0.0197	0.00840	0.00433
	(0.0183)	(0.0178)	(0.0125)	(0.0115)
Age (Years)	-0.00256***	-0.00191***	-0.00632***	-0.00693***
	(0.000117)	(0.000115)	(0.000396)	(0.000280)
Age^2	-2.23e-05***	-2.47e-05***	1.80e-05***	2.27e-05***
	(1.10e-06)	(1.07e-06)	(4.47e-06)	(2.84e-06)
Age Unknown	-0.162***	-0.166***	-0.134***	-0.126***
	(0.0105)	(0.0103)	(0.0211)	(0.0175)

Table A1.3 (continued)

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Fireplace	0.139***	0.128***	0.0496***	0.0494***
	(0.00260)	(0.00255)	(0.00397)	(0.00300)
Basement	0.163***	0.165***	0.151***	0.142***
	(0.00261)	(0.00256)	(0.00436)	(0.00347)
Finished Basement	0.0387***	0.0249***	0.0323***	0.0326***
	(0.00322)	(0.00320)	(0.00444)	(0.00310)
Central Air	0.398***	0.385***	0.259***	0.251***
	(0.00390)	(0.00381)	(0.00932)	(0.00682)
Brick Exterior	0.0599***	0.0489***	0.0404***	0.0352***
	(0.00243)	(0.00239)	(0.00342)	(0.00267)
Vinyl Exterior	-0.0798***	-0.0776***	-0.0179***	-0.0110**
	(0.00319)	(0.00312)	(0.00569)	(0.00489)
Metal Roof	-0.0736***	-0.0354***	-0.0127	-0.0101
	(0.0119)	(0.0117)	(0.0163)	(0.0154)
Composition Roof	-0.0307***	-0.000630	0.0156**	0.0176***
	(0.00491)	(0.00505)	(0.00682)	(0.00555)
Ranch Style	0.0708***	0.0878***	0.0619***	0.0560***
	(0.00266)	(0.00269)	(0.00396)	(0.00317)
Modular Style	-0.516***	-0.484***	-0.476***	-0.479***
	(0.00977)	(0.00957)	(0.0147)	(0.0149)
Cape Cod Style	0.0970***	0.106***	0.0475***	0.0407***
	(0.00408)	(0.00405)	(0.00570)	(0.00438)
Carport	0.0451***	0.0475***	0.0131**	0.00930**
	(0.00514)	(0.00502)	(0.00531)	(0.00454)
Garage	0.0855***	0.0953***	0.00487	0.00418
	(0.00331)	(0.00324)	(0.00556)	(0.00463)
One Car Garage	0.121***	0.112***	0.0927***	0.0877***
	(0.00423)	(0.00413)	(0.00595)	(0.00531)
Multiple Car Garage	0.128***	0.125***	0.144***	0.140***
	(0.00392)	(0.00383)	(0.00659)	(0.00546)
Within 1 Mile Parkway/Interstate	-0.00258	-0.00855***	-0.0288***	-0.0212***
	(0.00232)	(0.00226)	(0.00953)	(0.00699)
Within 1 Mile Railroad	-0.0817***	-0.0855***	-0.0153*	-0.0258***
	(0.00227)	(0.00222)	(0.00907)	(0.00685)
Within 1 Mile Ft. Knox	-0.205***	-0.202***	-0.0749**	-0.0574*
	(0.00926)	(0.00904)	(0.0348)	(0.0332)
Constant	10.29***	10.28***	10.56***	10.28***
	(0.00994)	(0.0202)	(0.0302)	(0.0187)
Observations	142,161	142,161	142,161	142,161
R-squared	0.703	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

Table A1.4: Cross-Section Regression Results Showing the Effect of Towers Only on Property Values using a Continuous Measure of Distance. Central Kentucky Data, 2000-2011. All Variables.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance to Tower	-0.00446***	-0.00737***	0.0119***	0.0109***
	(0.000597)[b]	(0.000585)	(0.00213)	(0.00187)
Distance^2 to Tower	2.23e-05	6.31e-05***	-0.000357***	-0.000335***
	(2.24e-05)	(2.19e-05)	(6.54e-05)	(6.04e-05)
Bedrooms	-0.00246	-0.00462**	0.0204***	0.0227***
	(0.00188)	(0.00184)	(0.00388)	(0.00285)
Full Bathrooms	0.110***	0.127***	0.0925***	0.0896***
	(0.00245)	(0.00241)	(0.00343)	(0.00266)
Partial Bathrooms	0.0631***	0.0729***	0.0485***	0.0461***
	(0.00262)	(0.00257)	(0.00391)	(0.00300)
Square Feet of Living Space	0.000559***	0.000567***	0.000414***	0.000401***
	(6.20e-06)	(6.06e-06)	(1.24e-05)	(1.03e-05)
Square Feet^2	-3.21e-08***	-3.43e-08***	-2.10e-08***	-2.15e-08***
	(1.02e-09)	(9.97e-10)	(2.48e-09)	(1.94e-09)
Lotsize (Acres)	0.0148***	0.0148***	0.0200***	0.0202***
	(0.000397)	(0.000387)	(0.00135)	(0.00126)
Lotsize^2	-3.90e-05***	-3.94e-05***	-5.83e-05***	-5.83e-05***
	(1.91e-06)	(1.86e-06)	(8.76e-06)	(8.76e-06)
Lotsize Missing	0.0569***	0.0154***	-0.00987**	-0.00852**
	(0.00510)	(0.00504)	(0.00440)	(0.00390)
Has $<$ in Lot Dimensions	0.0247***	-0.00480	-0.0218***	-0.0210***
	(0.00325)	(0.00320)	(0.00356)	(0.00287)
Has $>$ in Lot Dimensions	0.0339*	0.0165	0.00923	0.00477
	(0.0183)	(0.0178)	(0.0124)	(0.0114)
Age (Years)	-0.00263***	-0.00205***	-0.00629***	-0.00692***
	(0.000118)	(0.000115)	(0.000396)	(0.000280)
Age^2	-2.12e-05***	-2.33e-05***	1.80e-05***	2.28e-05***
	(1.10e-06)	(1.08e-06)	(4.45e-06)	(2.83e-06)
Age Unknown	-0.161***	-0.162***	-0.133***	-0.126***
	(0.0106)	(0.0103)	(0.0209)	(0.0174)

Table A1.4 (continued)

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Fireplace	0.138***	0.126***	0.0498***	0.0495***
	(0.00260)	(0.00256)	(0.00394)	(0.00300)
Basement	0.164***	0.167***	0.151***	0.142***
	(0.00262)	(0.00256)	(0.00440)	(0.00346)
Finished Basement	0.0391***	0.0254***	0.0320***	0.0325***
	(0.00323)	(0.00320)	(0.00443)	(0.00309)
Central Air	0.397***	0.383***	0.259***	0.251***
	(0.00390)	(0.00381)	(0.00927)	(0.00680)
Brick Exterior	0.0606***	0.0494***	0.0404***	0.0351***
	(0.00243)	(0.00239)	(0.00340)	(0.00267)
Vinyl Exterior	-0.0786***	-0.0759***	-0.0178***	-0.0112**
	(0.00320)	(0.00312)	(0.00573)	(0.00489)
Metal Roof	-0.0683***	-0.0256**	-0.0153	-0.0124
	(0.0119)	(0.0117)	(0.0164)	(0.0155)
Composition Roof	-0.0316***	-0.000844	0.0154**	0.0175***
	(0.00492)	(0.00505)	(0.00686)	(0.00559)
Ranch Style	0.0711***	0.0901***	0.0613***	0.0560***
	(0.00267)	(0.00270)	(0.00399)	(0.00318)
Modular Style	-0.508***	-0.470***	-0.478***	-0.481***
	(0.00981)	(0.00961)	(0.0147)	(0.0148)
Cape Cod Style	0.0974***	0.108***	0.0473***	0.0406***
	(0.00409)	(0.00405)	(0.00570)	(0.00440)
Carport	0.0463***	0.0494***	0.0135**	0.00966**
	(0.00514)	(0.00502)	(0.00532)	(0.00455)
Garage	0.0872***	0.0977***	0.00524	0.00437
	(0.00331)	(0.00324)	(0.00557)	(0.00461)
One Car Garage	0.119***	0.110***	0.0928***	0.0876***
	(0.00423)	(0.00414)	(0.00593)	(0.00528)
Multiple Car Garage	0.127***	0.123***	0.143***	0.140***
	(0.00392)	(0.00383)	(0.00654)	(0.00543)
Within 1 Mile Parkway/Interstate	-0.00583**	-0.0160***	-0.0240**	-0.0163**
	(0.00238)	(0.00233)	(0.00983)	(0.00709)
Within 1 Mile Railroad	-0.0849***	-0.0909***	-0.0132	-0.0239***
	(0.00230)	(0.00224)	(0.00924)	(0.00698)
Within 1 Mile Ft. Knox	-0.209***	-0.209***	-0.0768**	-0.0569*
	(0.00928)	(0.00905)	(0.0342)	(0.0319)
Constant	10.34***	10.36***	10.49***	10.22***
	(0.0104)	(0.0204)	(0.0315)	(0.0205)
Observations	142,161	142,161	142,161	142,161
R-squared	0.702	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

Table A1.5: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values Using the Nearest Antenna Method with the Closest Rings Combined. Central Kentucky Sales Data. 2000-2011. All Variables.

	(1)	(2)	(3)	(4)
VARIABLES	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)
Distance0to600	0.131***	0.140***	-0.0630***	-0.0572***
	(0.0136)	(0.0133)	(0.0196)	(0.0178)
Distance600to900	0.0982***	0.111***	-0.0756***	-0.0699***
	(0.0106)	(0.0104)	(0.0168)	(0.0152)
Distance900to1200	0.105***	0.121***	-0.0697***	-0.0727***
	(0.00829)	(0.00809)	(0.0160)	(0.0141)
Distance1200to1500	0.110***	0.122***	-0.0509***	-0.0581***
	(0.00689)	(0.00672)	(0.0119)	(0.0107)
Distance1500to1800	0.0798***	0.0911***	-0.0600***	-0.0687***
	(0.00634)	(0.00619)	(0.0114)	(0.0106)
Distance1800to2100	0.0623***	0.0736***	-0.0516***	-0.0544***
	(0.00603)	(0.00589)	(0.0113)	(0.0102)
Distance2100to2400	0.0425***	0.0565***	-0.0511***	-0.0536***
	(0.00554)	(0.00541)	(0.0114)	(0.00964)
Distance2400to2700	0.0413***	0.0547***	-0.0476***	-0.0448***
	(0.00535)	(0.00523)	(0.0106)	(0.00862)
Distance2700to3000	0.0115**	0.0239***	-0.0512***	-0.0457***
	(0.00510)	(0.00499)	(0.0108)	(0.00849)
Distance3000to3300	0.00454	0.0164***	-0.0525***	-0.0489***
	(0.00504)	(0.00492)	(0.00990)	(0.00825)
Distance3300to3600	0.0232***	0.0337***	-0.0406***	-0.0360***
	(0.00507)	(0.00495)	(0.00940)	(0.00778)
Distance3600to3900	0.0130***	0.0230***	-0.0419***	-0.0356***
	(0.00501)	(0.00489)	(0.00918)	(0.00712)
Distance3900to4200	0.0239***	0.0327***	-0.0275***	-0.0201***
	(0.00505)	(0.00493)	(0.00837)	(0.00660)
Distance4200to4500	0.0210***	0.0270***	-0.0168**	-0.00857
	(0.00521)	(0.00509)	(0.00707)	(0.00627)
Bedrooms	-0.00126	-0.00326*	0.0203***	0.0228***
	(0.00188)	(0.00184)	(0.00373)	(0.00269)
Full Bathrooms	0.110***	0.128***	0.0919***	0.0891***
	(0.00244)	(0.00241)	(0.00329)	(0.00262)
Partial Bathrooms	0.0645***	0.0748***	0.0480***	0.0459***
	(0.00261)	(0.00256)	(0.00368)	(0.00288)
Square Feet of Living Space	0.000559***	0.000567***	0.000415***	0.000401***
	(6.19e-06)	(6.06e-06)	(1.23e-05)	(1.04e-05)
Square Feet^2	-3.19e-08***	-3.40e-08***	-2.11e-08***	-2.15e-08***
	(1.02e-09)	(9.95e-10)	(2.47e-09)	(1.97e-09)
Lotsize (Acres)	0.0142***	0.0140***	0.0201***	0.0203***
	(0.000392)	(0.000382)	(0.00134)	(0.00126)
Lotsize^2	-3.71e-05***	-3.64e-05***	-5.87e-05***	-5.86e-05***
	(1.89e-06)	(1.85e-06)	(8.85e-06)	(8.84e-06)
Lotsize Missing	0.0574***	0.0169***	-0.0100**	-0.00844**
	(0.00509)	(0.00503)	(0.00422)	(0.00377)
Has $<$ in Lot Dimensions	0.0269***	-0.00157	-0.0218***	-0.0209***
	(0.00324)	(0.00319)	(0.00343)	(0.00281)
Has $>$ in Lot Dimensions	0.0369**	0.0203	0.00781	0.00404
	(0.0182)	(0.0178)	(0.0122)	(0.0114)

Table A1.5 (continued)

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Age (Years)	-0.00258***	-0.00197***	-0.00632***	-0.00693***
	(0.000117)	(0.000115)	(0.000375)	(0.000277)
Age^2	-2.27e-05***	-2.50e-05***	1.82e-05***	2.30e-05***
	(1.10e-06)	(1.07e-06)	(4.24e-06)	(2.81e-06)
Age Unknown	-0.162***	-0.164***	-0.134***	-0.126***
	(0.0105)	(0.0103)	(0.0203)	(0.0174)
Fireplace	0.138***	0.126***	0.0499***	0.0497***
	(0.00260)	(0.00255)	(0.00385)	(0.00291)
Basement	0.162***	0.165***	0.151***	0.142***
	(0.00261)	(0.00255)	(0.00434)	(0.00336)
Finished Basement	0.0391***	0.0254***	0.0320***	0.0326***
	(0.00322)	(0.00319)	(0.00434)	(0.00308)
Central Air	0.397***	0.383***	0.259***	0.251***
	(0.00389)	(0.00381)	(0.00905)	(0.00683)
Brick Exterior	0.0602***	0.0492***	0.0403***	0.0350***
	(0.00243)	(0.00238)	(0.00323)	(0.00251)
Vinyl Exterior	-0.0798***	-0.0775***	-0.0172***	-0.0110**
	(0.00319)	(0.00312)	(0.00553)	(0.00481)
Metal Roof	-0.0719***	-0.0320***	-0.0148	-0.0117
	(0.0119)	(0.0117)	(0.0163)	(0.0154)
Composition Roof	-0.0308***	-0.000276	0.0151**	0.0172***
	(0.00491)	(0.00504)	(0.00667)	(0.00539)
Ranch Style	0.0714***	0.0891***	0.0618***	0.0560***
	(0.00266)	(0.00269)	(0.00391)	(0.00305)
Modular Style	-0.515***	-0.481***	-0.476***	-0.479***
	(0.00977)	(0.00957)	(0.0154)	(0.0150)
Cape Cod Style	0.0958***	0.105***	0.0477***	0.0408***
	(0.00408)	(0.00405)	(0.00565)	(0.00440)
Carport	0.0448***	0.0471***	0.0138***	0.00985**
	(0.00514)	(0.00502)	(0.00520)	(0.00456)
Garage	0.0845***	0.0942***	0.00528	0.00452
	(0.00330)	(0.00324)	(0.00542)	(0.00452)
One Car Garage	0.121***	0.112***	0.0926***	0.0875***
	(0.00422)	(0.00413)	(0.00585)	(0.00523)
Multiple Car Garage	0.129***	0.127***	0.144***	0.140***
	(0.00391)	(0.00383)	(0.00647)	(0.00536)
Within 1 Mile Parkway/Interstate	-0.00430*	-0.0118***	-0.0281***	-0.0192**
	(0.00234)	(0.00229)	(0.00977)	(0.00751)
Within 1 Mile Railroad	-0.0815***	-0.0852***	-0.0149*	-0.0255***
	(0.00227)	(0.00222)	(0.00905)	(0.00692)
Within 1 Mile Ft. Knox	-0.206***	-0.204***	-0.0734**	-0.0535
	(0.00926)	(0.00904)	(0.0320)	(0.0328)
Constant	10.29***	10.28***	10.56***	10.30***
	(0.00993)	(0.0201)	(0.0295)	(0.0194)
Observations	142,164	142,164	142,164	142,164
R-squared	0.703	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

Table A1.6: Cross-Section Regression Results Showing the Effect of Towers Only on Property Values Using the Nearest Antenna Method with the Closest Rings Combined. Central Kentucky Sales Data. 2000-2011. All Variables.

	(1)	(2)	(3)	(4)
VARIABLES	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)
TowerDistance0to600	0.124***	0.135***	-0.0645***	-0.0503**
	(0.0155)	(0.0151)	(0.0232)	(0.0213)
TowerDistance600to900	0.0828***	0.0960***	-0.0798***	-0.0680***
	(0.0120)	(0.0118)	(0.0185)	(0.0175)
TowerDistance900to1200	0.0894***	0.106***	-0.0726***	-0.0726***
	(0.00940)	(0.00918)	(0.0205)	(0.0165)
TowerDistance1200to1500	0.0897***	0.104***	-0.0567***	-0.0620***
	(0.00772)	(0.00754)	(0.0132)	(0.0121)
TowerDistance1500to1800	0.0592***	0.0732***	-0.0652***	-0.0720***
	(0.00702)	(0.00686)	(0.0126)	(0.0119)
TowerDistance1800to2100	0.0494***	0.0625***	-0.0554***	-0.0596***
	(0.00660)	(0.00645)	(0.0128)	(0.0112)
TowerDistance2100to2400	0.0267***	0.0426***	-0.0538***	-0.0582***
	(0.00597)	(0.00583)	(0.0126)	(0.0105)
TowerDistance2400to2700	0.0212***	0.0364***	-0.0538***	-0.0540***
	(0.00579)	(0.00566)	(0.0116)	(0.00930)
TowerDistance2700to3000	-0.0122**	0.00154	-0.0558***	-0.0546***
	(0.00555)	(0.00542)	(0.0116)	(0.00916)
TowerDistance3000to3300	-0.0199***	-0.00485	-0.0522***	-0.0516***
	(0.00541)	(0.00529)	(0.0108)	(0.00902)
TowerDistance3300to3600	-0.00121	0.0114**	-0.0471***	-0.0424***
	(0.00539)	(0.00526)	(0.0103)	(0.00842)
TowerDistance3600to3900	0.000655	0.0134***	-0.0445***	-0.0411***
	(0.00519)	(0.00507)	(0.00888)	(0.00757)
TowerDistance3900to4200	0.0222***	0.0327***	-0.0279***	-0.0253***
	(0.00514)	(0.00502)	(0.00843)	(0.00723)
TowerDistance4200to4500	0.0182***	0.0276***	-0.0201***	-0.0139**
	(0.00529)	(0.00517)	(0.00717)	(0.00662)
Bedrooms	-0.00110	-0.00298	0.0202***	0.0227***
	(0.00188)	(0.00184)	(0.00375)	(0.00268)
Full Bathrooms	0.110***	0.127***	0.0923***	0.0893***
	(0.00245)	(0.00241)	(0.00329)	(0.00260)
Partial Bathrooms	0.0646***	0.0747***	0.0484***	0.0461***
	(0.00261)	(0.00256)	(0.00370)	(0.00287)
Square Feet of Living Space	0.000558***	0.000565***	0.000414***	0.000401***
	(6.20e-06)	(6.06e-06)	(1.24e-05)	(1.04e-05)
Square Feet^2	-3.19e-08***	-3.39e-08***	-2.10e-08***	-2.14e-08***
	(1.02e-09)	(9.96e-10)	(2.49e-09)	(1.96e-09)
Lotsize (Acres)	0.0140***	0.0137***	0.0201***	0.0203***
	(0.000392)	(0.000382)	(0.00134)	(0.00126)
Lotsize^2	-3.62e-05***	-3.55e-05***	-5.87e-05***	-5.85e-05***
	(1.89e-06)	(1.85e-06)	(8.86e-06)	(8.85e-06)
Lotsize Missing	0.0579***	0.0179***	-0.0102**	-0.00853**
	(0.00510)	(0.00504)	(0.00419)	(0.00377)
Has $<$ in Lot Dimensions	0.0278***	-0.000432	-0.0218***	-0.0210***
	(0.00324)	(0.00320)	(0.00342)	(0.00281)
Has $>$ in Lot Dimensions	0.0349*	0.0185	0.00824	0.00406
	(0.0183)	(0.0178)	(0.0122)	(0.0114)

Table A1.6 (continued)

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Age (Years)	-0.00246***	-0.00183***	-0.00629***	-0.00693***
	(0.000117)	(0.000115)	(0.000375)	(0.000277)
Age^2	-2.33e-05***	-2.58e-05***	1.81e-05***	2.30e-05***
	(1.10e-06)	(1.08e-06)	(4.23e-06)	(2.80e-06)
Age Unknown	-0.166***	-0.168***	-0.134***	-0.126***
	(0.0105)	(0.0103)	(0.0203)	(0.0173)
Fireplace	0.138***	0.127***	0.0498***	0.0497***
	(0.00260)	(0.00256)	(0.00385)	(0.00292)
Basement	0.163***	0.165***	0.151***	0.142***
	(0.00261)	(0.00256)	(0.00434)	(0.00334)
Finished Basement	0.0380***	0.0246***	0.0322***	0.0325***
	(0.00322)	(0.00320)	(0.00432)	(0.00307)
Central Air	0.398***	0.385***	0.258***	0.251***
	(0.00390)	(0.00381)	(0.00905)	(0.00682)
Brick Exterior	0.0609***	0.0502***	0.0402***	0.0350***
	(0.00243)	(0.00239)	(0.00325)	(0.00251)
Vinyl Exterior	-0.0801***	-0.0780***	-0.0171***	-0.0108**
	(0.00319)	(0.00312)	(0.00555)	(0.00481)
Metal Roof	-0.0735***	-0.0343***	-0.0145	-0.0115
	(0.0119)	(0.0117)	(0.0163)	(0.0155)
Composition Roof	-0.0304***	-0.000416	0.0153**	0.0172***
	(0.00491)	(0.00505)	(0.00667)	(0.00540)
Ranch Style	0.0703***	0.0878***	0.0619***	0.0562***
	(0.00267)	(0.00270)	(0.00394)	(0.00305)
Modular Style	-0.518***	-0.484***	-0.476***	-0.479***
	(0.00977)	(0.00958)	(0.0154)	(0.0150)
Cape Cod Style	0.0962***	0.106***	0.0475***	0.0406***
	(0.00408)	(0.00405)	(0.00567)	(0.00439)
Carport	0.0458***	0.0484***	0.0135***	0.00989**
	(0.00514)	(0.00502)	(0.00521)	(0.00456)
Garage	0.0856***	0.0952***	0.00524	0.00453
	(0.00331)	(0.00324)	(0.00541)	(0.00452)
One Car Garage	0.121***	0.112***	0.0925***	0.0874***
	(0.00423)	(0.00413)	(0.00581)	(0.00522)
Multiple Car Garage	0.129***	0.126***	0.144***	0.140***
	(0.00392)	(0.00383)	(0.00644)	(0.00535)
Within 1 Mile Parkway/Interstate	-0.000183	-0.00760***	-0.0263***	-0.0180**
	(0.00233)	(0.00228)	(0.00973)	(0.00746)
Within 1 Mile Railroad	-0.0808***	-0.0846***	-0.0145	-0.0252***
	(0.00227)	(0.00222)	(0.00913)	(0.00700)
Within 1 Mile Ft. Knox	-0.206***	-0.205***	-0.0727**	-0.0527
	(0.00927)	(0.00905)	(0.0319)	(0.0326)
Constant	10.30***	10.29***	10.55***	10.30***
	(0.00993)	(0.0202)	(0.0295)	(0.0196)
Observations	142,164	142,164	142,164	142,164
R-squared	0.703	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	Yes	No	Yes
Block Group Fixed Effects	No	No	No	Yes

Table A1.7: Cross-Section Regression Results Showing the Effect of All Antennas on Property Values Using the Antenna Count Method with the Closest Rings Combined. Central Kentucky Sales Data. 2000-2011. All Variables.

	(1)	(2)	(3)	(4)
VARIABLES	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)
Count0to600	0.0993***	0.100***	-0.0384**	-0.0307**
	(0.0129)	(0.0126)	(0.0166)	(0.0148)
Count600to900	0.0636***	0.0693***	-0.0502***	-0.0458***
	(0.00981)	(0.00957)	(0.0146)	(0.0133)
Count900to1200	0.0697***	0.0784***	-0.0432***	-0.0483***
	(0.00766)	(0.00748)	(0.0131)	(0.0118)
Count1200to1500	0.0732***	0.0787***	-0.0307***	-0.0371***
	(0.00617)	(0.00602)	(0.00973)	(0.00900)
Count1500to1800	0.0493***	0.0536***	-0.0397***	-0.0480***
	(0.00551)	(0.00538)	(0.00810)	(0.00769)
Count1800to2100	0.0453***	0.0494***	-0.0291***	-0.0315***
	(0.00502)	(0.00490)	(0.00795)	(0.00719)
Count2100to2400	0.0299***	0.0363***	-0.0264***	-0.0303***
	(0.00451)	(0.00440)	(0.00870)	(0.00702)
Count2400to2700	0.0305***	0.0362***	-0.0289***	-0.0277***
	(0.00418)	(0.00408)	(0.00706)	(0.00635)
Count2700to3000	0.00339	0.00958**	-0.0307***	-0.0286***
	(0.00385)	(0.00376)	(0.00739)	(0.00608)
Count3000to3300	0.00398	0.00951***	-0.0299***	-0.0311***
	(0.00362)	(0.00353)	(0.00694)	(0.00557)
Count3300to3600	0.0167***	0.0213***	-0.0251***	-0.0239***
	(0.00349)	(0.00340)	(0.00608)	(0.00482)
Count3600to3900	0.00973***	0.0147***	-0.0291***	-0.0274***
	(0.00323)	(0.00315)	(0.00626)	(0.00504)
Count3900to4200	0.0255***	0.0304***	-0.0237***	-0.0196***
	(0.00306)	(0.00299)	(0.00652)	(0.00465)
Count4200to4500	0.0215***	0.0266***	-0.0191***	-0.0140***
	(0.00302)	(0.00295)	(0.00613)	(0.00458)
Bedrooms	-0.00113	-0.00309*	0.0205***	0.0229***
	(0.00188)	(0.00184)	(0.00376)	(0.00270)
Full Bathrooms	0.110***	0.127***	0.0920***	0.0891***
	(0.00244)	(0.00241)	(0.00330)	(0.00263)
Partial Bathrooms	0.0649***	0.0754***	0.0486***	0.0462***
	(0.00261)	(0.00256)	(0.00371)	(0.00288)
Square Feet of Living Space	0.000560***	0.000568***	0.000414***	0.000400***
	(6.20e-06)	(6.06e-06)	(1.23e-05)	(1.04e-05)
Square Feet^2	-3.20e-08***	-3.42e-08***	-2.10e-08***	-2.13e-08***
	(1.02e-09)	(9.95e-10)	(2.48e-09)	(1.97e-09)
Lotsize (Acres)	0.0141***	0.0139***	0.0201***	0.0202***
	(0.000390)	(0.000381)	(0.00136)	(0.00127)
Lotsize^2	-3.70e-05***	-3.61e-05***	-5.86e-05***	-5.84e-05***
	(1.89e-06)	(1.84e-06)	(8.94e-06)	(8.87e-06)
Lotsize Missing	0.0581***	0.0172***	-0.0103**	-0.00854**
	(0.00509)	(0.00503)	(0.00418)	(0.00376)
Has $<$ in Lot Dimensions	0.0272***	-0.00113	-0.0221***	-0.0211***
	(0.00324)	(0.00319)	(0.00345)	(0.00283)
Has $>$ in Lot Dimensions	0.0367**	0.0199	0.00671	0.00363
	(0.0183)	(0.0178)	(0.0121)	(0.0113)

Table A1.7 (continued)

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Age (Years)	-0.00256***	-0.00192***	-0.00637***	-0.00697***
	(0.000117)	(0.000115)	(0.000378)	(0.000280)
Age^2	-2.35e-05***	-2.61e-05***	1.88e-05***	2.34e-05***
	(1.10e-06)	(1.08e-06)	(4.23e-06)	(2.83e-06)
Age Unknown	-0.165***	-0.168***	-0.136***	-0.128***
	(0.0105)	(0.0103)	(0.0207)	(0.0175)
Fireplace	0.138***	0.126***	0.0496***	0.0496***
	(0.00260)	(0.00255)	(0.00381)	(0.00290)
Basement	0.162***	0.165***	0.152***	0.143***
	(0.00261)	(0.00255)	(0.00431)	(0.00337)
Finished Basement	0.0398***	0.0259***	0.0324***	0.0327***
	(0.00322)	(0.00319)	(0.00434)	(0.00308)
Central Air	0.396***	0.383***	0.258***	0.251***
	(0.00389)	(0.00381)	(0.00904)	(0.00684)
Brick Exterior	0.0597***	0.0485***	0.0406***	0.0354***
	(0.00243)	(0.00238)	(0.00326)	(0.00252)
Vinyl Exterior	-0.0800***	-0.0778***	-0.0170***	-0.0107**
	(0.00319)	(0.00311)	(0.00558)	(0.00483)
Metal Roof	-0.0728***	-0.0329***	-0.0176	-0.0138
	(0.0118)	(0.0117)	(0.0162)	(0.0155)
Composition Roof	-0.0327***	-0.00198	0.0127*	0.0152***
	(0.00491)	(0.00504)	(0.00654)	(0.00538)
Ranch Style	0.0722***	0.0900***	0.0616***	0.0562***
	(0.00266)	(0.00269)	(0.00394)	(0.00307)
Modular Style	-0.514***	-0.482***	-0.477***	-0.480***
	(0.00977)	(0.00957)	(0.0156)	(0.0151)
Cape Cod Style	0.0944***	0.104***	0.0477***	0.0412***
	(0.00408)	(0.00405)	(0.00567)	(0.00443)
Carport	0.0465***	0.0488***	0.0142***	0.0104**
	(0.00514)	(0.00502)	(0.00526)	(0.00458)
Garage	0.0850***	0.0949***	0.00566	0.00498
	(0.00330)	(0.00324)	(0.00544)	(0.00450)
One Car Garage	0.121***	0.113***	0.0923***	0.0871***
	(0.00422)	(0.00413)	(0.00585)	(0.00515)
Multiple Car Garage	0.131***	0.128***	0.143***	0.139***
	(0.00392)	(0.00383)	(0.00643)	(0.00528)
Within 1 Mile Parkway/Interstate	-0.00640***	-0.0139***	-0.0281***	-0.0193**
	(0.00234)	(0.00229)	(0.00964)	(0.00771)
Within 1 Mile Railroad	-0.0838***	-0.0882***	-0.0128	-0.0232***
	(0.00228)	(0.00222)	(0.00906)	(0.00691)
Within 1 Mile Ft. Knox	-0.204***	-0.201***	-0.0747**	-0.0555
	(0.00925)	(0.00903)	(0.0327)	(0.0339)
Constant	10.29***	10.29***	10.56***	10.31***
	(0.00992)	(0.0201)	(0.0294)	(0.0206)
Observations	142,164	142,164	142,164	142,164
R-squared	0.703	0.718	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

Table A1.8: Cross-Section Regression Results Showing the Effect of Towers Only on Property Values Using Antenna Count Method with the Closest Rings Combined. Central Kentucky Sales Data. 2000-2011. All Variables.

	(1)	(2)	(3)	(4)
VARIABLES	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)	ln(Sales Price)
TowerCount0to600	0.103***	0.106***	-0.0459**	-0.0317*
	(0.0150)	(0.0146)	(0.0211)	(0.0188)
TowerCount600to900	0.0602***	0.0669***	-0.0661***	-0.0555***
	(0.0117)	(0.0114)	(0.0164)	(0.0155)
TowerCount900to1200	0.0670***	0.0772***	-0.0586***	-0.0591***
	(0.00909)	(0.00887)	(0.0183)	(0.0152)
TowerCount1200to1500	0.0634***	0.0715***	-0.0490***	-0.0521***
	(0.00736)	(0.00718)	(0.0133)	(0.0113)
TowerCount1500to1800	0.0374***	0.0452***	-0.0581***	-0.0614***
	(0.00663)	(0.00648)	(0.0103)	(0.00973)
TowerCount1800to2100	0.0318***	0.0395***	-0.0451***	-0.0474***
	(0.00603)	(0.00589)	(0.0100)	(0.00906)
TowerCount2100to2400	0.0125**	0.0223***	-0.0407***	-0.0452***
	(0.00536)	(0.00524)	(0.0109)	(0.00908)
TowerCount2400to2700	0.0164***	0.0255***	-0.0402***	-0.0422***
	(0.00499)	(0.00487)	(0.00895)	(0.00763)
TowerCount2700to3000	-0.00973**	-0.000863	-0.0403***	-0.0419***
	(0.00464)	(0.00454)	(0.00987)	(0.00804)
TowerCount3000to3300	-0.0140***	-0.00411	-0.0425***	-0.0446***
	(0.00437)	(0.00427)	(0.00865)	(0.00714)
TowerCount3300to3600	-0.00606	0.00189	-0.0393***	-0.0384***
	(0.00425)	(0.00415)	(0.00759)	(0.00637)
TowerCount3600to3900	-0.00697*	0.00108	-0.0392***	-0.0385***
	(0.00388)	(0.00379)	(0.00748)	(0.00614)
TowerCount3900to4200	0.0218***	0.0284***	-0.0279***	-0.0274***
	(0.00369)	(0.00361)	(0.00754)	(0.00583)
TowerCount4200to4500	0.0165***	0.0243***	-0.0203***	-0.0185***
	(0.00360)	(0.00352)	(0.00716)	(0.00558)
Bedrooms	-0.00136	-0.00316*	0.0204***	0.0229***
	(0.00188)	(0.00184)	(0.00376)	(0.00269)
Full Bathrooms	0.110***	0.127***	0.0920***	0.0890***
	(0.00245)	(0.00241)	(0.00330)	(0.00260)
Partial Bathrooms	0.0649***	0.0751***	0.0486***	0.0462***
	(0.00261)	(0.00257)	(0.00371)	(0.00288)
Square Feet of Living Space	0.000558***	0.000565***	0.000413***	0.000400***
	(6.20e-06)	(6.07e-06)	(1.24e-05)	(1.03e-05)
Square Feet^2	-3.19e-08***	-3.39e-08***	-2.09e-08***	-2.13e-08***
	(1.02e-09)	(9.97e-10)	(2.48e-09)	(1.95e-09)
Lotsize (Acres)	0.0138***	0.0136***	0.0200***	0.0201***
	(0.000391)	(0.000382)	(0.00136)	(0.00127)
Lotsize^2	-3.60e-05***	-3.52e-05***	-5.85e-05***	-5.83e-05***
	(1.89e-06)	(1.85e-06)	(8.93e-06)	(8.87e-06)
Lotsize Missing	0.0581***	0.0182***	-0.0102**	-0.00871**
	(0.00510)	(0.00504)	(0.00417)	(0.00375)
Has $<$ in Lot Dimensions	0.0279***	5.40e-06	-0.0219***	-0.0212***
	(0.00325)	(0.00320)	(0.00343)	(0.00283)
Has $>$ in Lot Dimensions	0.0345*	0.0180	0.00789	0.00386
	(0.0183)	(0.0179)	(0.0121)	(0.0113)

Table A1.8 (continued)

VARIABLES	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Age (Years)	-0.00244***	-0.00179***	-0.00634***	-0.00696***
	(0.000117)	(0.000115)	(0.000377)	(0.000279)
Age^2	-2.33e-05***	-2.63e-05***	1.88e-05***	2.35e-05***
	(1.11e-06)	(1.08e-06)	(4.20e-06)	(2.81e-06)
Age Unknown	-0.169***	-0.171***	-0.136***	-0.128***
	(0.0105)	(0.0103)	(0.0206)	(0.0174)
Fireplace	0.139***	0.127***	0.0496***	0.0495***
	(0.00260)	(0.00256)	(0.00381)	(0.00290)
Basement	0.163***	0.165***	0.151***	0.142***
	(0.00262)	(0.00256)	(0.00431)	(0.00334)
Finished Basement	0.0383***	0.0248***	0.0328***	0.0329***
	(0.00323)	(0.00320)	(0.00432)	(0.00307)
Central Air	0.398***	0.385***	0.258***	0.250***
	(0.00390)	(0.00381)	(0.00903)	(0.00683)
Brick Exterior	0.0606***	0.0497***	0.0405***	0.0354***
	(0.00243)	(0.00239)	(0.00327)	(0.00252)
Vinyl Exterior	-0.0798***	-0.0778***	-0.0168***	-0.0104**
	(0.00320)	(0.00312)	(0.00558)	(0.00484)
Metal Roof	-0.0750***	-0.0360***	-0.0174	-0.0139
	(0.0119)	(0.0117)	(0.0163)	(0.0155)
Composition Roof	-0.0322***	-0.00226	0.0128*	0.0150***
	(0.00492)	(0.00505)	(0.00653)	(0.00537)
Ranch Style	0.0701***	0.0875***	0.0618***	0.0562***
	(0.00267)	(0.00270)	(0.00396)	(0.00307)
Modular Style	-0.518***	-0.485***	-0.477***	-0.480***
	(0.00979)	(0.00959)	(0.0156)	(0.0151)
Cape Cod Style	0.0960***	0.105***	0.0475***	0.0407***
	(0.00409)	(0.00406)	(0.00565)	(0.00441)
Carport	0.0468***	0.0494***	0.0144***	0.0107**
	(0.00515)	(0.00503)	(0.00526)	(0.00458)
Garage	0.0865***	0.0964***	0.00581	0.00517
	(0.00331)	(0.00325)	(0.00542)	(0.00447)
One Car Garage	0.121***	0.113***	0.0918***	0.0867***
	(0.00423)	(0.00414)	(0.00580)	(0.00512)
Multiple Car Garage	0.128***	0.126***	0.143***	0.139***
	(0.00392)	(0.00384)	(0.00638)	(0.00525)
Within 1 Mile Parkway/Interstate	0.000163	-0.00718***	-0.0261***	-0.0181**
	(0.00233)	(0.00228)	(0.00977)	(0.00753)
Within 1 Mile Railroad	-0.0808***	-0.0854***	-0.0134	-0.0235***
	(0.00228)	(0.00223)	(0.00927)	(0.00702)
Within 1 Mile Ft. Knox	-0.204***	-0.203***	-0.0741**	-0.0536
	(0.00927)	(0.00906)	(0.0328)	(0.0337)
Constant	10.30***	10.29***	10.56***	10.34***
	(0.00993)	(0.0202)	(0.0294)	(0.0216)
Observations	142,164	142,164	142,164	142,164
R-squared	0.702	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes

Table A1.9: Cross-Section Regression Results Showing the Effect of Towers Only on Property Values using a Continuous Measure of Distance with the Density of Nearby Antennas. Central Kentucky Data, 2000-2011.

VARIABLES[a]	(1) ln(Sales Price)	(2) ln(Sales Price)	(3) ln(Sales Price)	(4) ln(Sales Price)
Distance to Tower	-0.00279***	-0.00530***	0.00646***	0.00477**
	(0.000781)[b]	(0.000763)	(0.00227)	(0.00203)
Distance^2 to Tower	-3.25e-05	-2.04e-06	-0.000210***	-0.000171***
	(2.67e-05)	(2.60e-05)	(6.43e-05)	(6.12e-05)
Constant	10.34***	10.35***	10.53***	10.31***
	(0.0110)	(0.0207)	(0.0339)	(0.0234)
Observations	142,161	142,161	142,161	142,161
R-squared	0.703	0.717	0.853	0.862
Year-Month Dummies	No	Yes	Yes	Yes
Tract Fixed Effects	No	No	Yes	No
Block Group Fixed Effects	No	No	No	Yes
Density of Towers[c]	Yes	Yes	Yes	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 1 mile Ft. Knox.

[b] Standard errors are clustered at the level of included fixed effects.

[c] Density is measured as the the number of antennas located within specified distances from the property.

*** p<0.01, ** p<0.05, * p<0.1

Table A1.10: Repeat Sales Regression Results Showing the Effect of Towers Only on Property Values Using a Continuous Measure of Distance. Constant Structural Characteristics. Central Kentucky Data, 2000-2011.

	(1)	(2)	(3)	(4)
VARIABLES	Δ ln(Sold Price)	Δ ln(Sold Price)	Δ ln(Sold Price)	Δ ln(Sold Price)
Δ Distance to Tower	0.0106***	0.0106***	0.0103***	0.00627***
	(0.00104)[a]	(0.00104)	(0.00106)	(0.00111)
Constant	0.0560***	0.0568***	0.0625***	0.151***
	(0.00308)	(0.00311)	(0.00332)	(0.00525)
Observations	29,886	29,719	28,387	20,976
R-squared	0.105	0.105	0.109	0.145
All Repeats	Yes	No	No	No
Four or Less	No	Yes	No	No
Three or Less	No	No	Yes	No
Sold Twice	No	No	No	Yes

[a] Standard errors are clustered at the property level.
*** p<0.01, ** p<0.05, * p<0.1

Table A1.11: Repeat Sales Regression Results Showing the Effect of Towers Only on Property Values Using a Continuous Measure of Distance. Changing Structural Characteristics. Central Kentucky Data, 2000-2011.

VARIABLES	(1) Δ ln(Sold Price)	(2) Δ ln(Sold Price)	(3) Δ ln(Sold Price)	(4) Δ ln(Sold Price)
Δ Distance to Tower	0.00977***	0.00971***	0.00950***	0.00600***
	(0.000977)[a]	(0.000979)	(0.000997)	(0.00105)
Δ Bedrooms	0.0783***	0.0768***	0.0738***	0.0619***
	(0.00557)	(0.00554)	(0.00557)	(0.00621)
Δ Full Bathrooms	0.169***	0.169***	0.169***	0.168***
	(0.00791)	(0.00793)	(0.00812)	(0.00896)
Δ Partial Bathrooms	0.104***	0.104***	0.105***	0.110***
	(0.00950)	(0.00951)	(0.00979)	(0.0113)
Δ Finished Basement	0.0210***	0.0213***	0.0210***	0.00978**
	(0.00383)	(0.00383)	(0.00393)	(0.00455)
Δ Central Air	0.254***	0.255***	0.250***	0.243***
	(0.00974)	(0.00978)	(0.0100)	(0.0115)
Δ Carport	0.0595***	0.0604***	0.0558***	0.0395***
	(0.0145)	(0.0146)	(0.0148)	(0.0151)
Δ Garage	0.0157**	0.0155**	0.0136*	0.0203**
	(0.00771)	(0.00775)	(0.00792)	(0.00898)
Constant	0.0367***	0.0374***	0.0424***	0.122***
	(0.00287)	(0.00289)	(0.00309)	(0.00489)
Observations	29,886	29,719	28,387	20,976
R-squared	0.203	0.204	0.205	0.231
All Repeats	Yes	No	No	No
Four or Less	No	Yes	No	No
Three or Less	No	No	Yes	No
Sold Twice	No	No	No	Yes

[a] Standard errors are clustered at the property level.
*** p<0.01, ** p<0.05, * p<0.1

A.2 Chapter 3 Appendix

First Order Conditions

Home Owner:

$$\Theta_F(L,S)(1-F(P_F)-P_F f(P_F))+$$

$$\left(\frac{\partial \Theta_F(L,S)}{\partial L}\frac{dL}{dP_F}+\frac{\partial \Theta_F(L,S)}{\partial S}\frac{dS}{dP_F}\right)P_F(1-F(P_F))=0 \qquad \text{(Franchised)}$$

$$\Theta_I(L,S)(1-F(P_I)-P_I f(P_I))+$$

$$\left(\frac{\partial \Theta_I(L,S)}{\partial L}\frac{dL}{dP_I}+\frac{\partial \Theta_I(L,S)}{\partial S}\frac{dS}{dP_I}\right)P_I(1-F(P_I))=0 \qquad \text{(Independent)}$$

Listing Broker:

$$(1-r)kP_F(1-F(P_F))\left[\frac{\partial \Gamma(L,S)}{\partial L}\mu+\frac{\partial \Phi_F(L,S)}{\partial L}\right]=C'(L) \qquad \text{(Franchised)}$$

$$kP_I(1-F(P_I))\left[\frac{\partial \Gamma(L,S)}{\partial L}\mu+\frac{\partial \Phi_I(L,S)}{\partial L}\right]=C'(L) \qquad \text{(Independent)}$$

Selling Broker:

$$\frac{\partial \Gamma(L,S)_i}{\partial S}(1-\mu)kP_i(1-F(P_i))=C'(S) \qquad \text{(i=I,F)}$$

Best Reply Functions

$$L_F^* = \frac{-2c_F(\alpha_F^l + nS\alpha_F^l\alpha_F^s) + \sqrt{Bc_Fk(-1+r){\alpha_F^l}^3(-1+nS\alpha_F^s(-1+\mu))}}{2c_F{\alpha_F^l}^2}$$

$$S_F^* = \frac{-2c_Fn(1+L\alpha_F^l)\alpha_F^s + \sqrt{-Bc_Fkn^2(1+L\alpha_F^l){\alpha_F^s}^3(-1+\mu)}}{2c_Fn^2{\alpha_F^s}^2}$$

$$L_I^* = \frac{-2c_I(\alpha_I^l + nS\alpha_I^l\alpha_I^s) + \sqrt{Bc_Ik{\alpha_I^l}^3(-1+nS\alpha_I^s(-1+\mu))}}{2c_I{\alpha_I^l}^2}$$

$$S_I^* = \frac{-2c_In(1+L\alpha_I^l)\alpha_I^s + \sqrt{-Bc_Ikn^2(1+L\alpha_I^l)\alpha_I^{s3}(-1+\mu)}}{2c_In^2\alpha_I^{s2}}$$

Table A2.1: Summary Statistics for Transaction and House Characteristics. Central Kentucky Data, 2000-2011. Sample Size=145,851

Variable	Mean	Std. Dev.	Min	Max
Transaction				
Sales Price (2011 Dollars)[a]	182,445	142,179	1,028	4,859,483
List Price (2011 Dollars)[a]	190,283	152,444	1,021	5,441,564
Degree Overpricing[b]	0	0.263	-2.831	2.71
Days on Market	84.697	83.872	0	1949
5 Miles Ft. Knox	0.094	0.292	0	1
% Out of State 5 Years Ago	8.976	5.297	0	74.02
% Out of State 1 Year Ago	10.646	19.444	0	115.52
Listed by Franchise	0.423	0.494	0	1
Sold by Franchise	0.39	0.488	0	1
# of Selling Agents in Listing Firm	98.54	158.032	0	573
Sold Own Listing	0.359	0.48	0	1
House				
Bedrooms	3.239	0.783	1	13
Full Bathrooms	1.812	0.749	1	9
Partial Bathrooms	0.366	0.521	0	6
Square Feet of Living Space	1,653	714	500	9688
Lotsize (Acres)	0.844	4.713	0	436
Lotsize Missing	0.045	0.208	0	1
Has $<$ in Lot Dimensions[c]	0.124	0.329	0	1
Has $>$ in Lot Dimensions[c]	0.003	0.057	0	1
Age (Years)	32.951	29.04	0	235
Age Unknown	0.01	0.102	0	1
Fireplace	0.475	0.499	0	1
Basement	0.6	0.49	0	1
Finished Basement	0.174	0.379	0	1
Central Air	0.908	0.29	0	1
Brick Exterior	0.345	0.475	0	1
Vinyl Exterior	0.167	0.373	0	1
Metal Roof	0.01	0.102	0	1
Composition Roof	0.939	0.24	0	1
Ranch Style	0.45	0.497	0	1
Modular Style	0.015	0.121	0	1
Cape Cod Style	0.084	0.277	0	1
Carport	0.057	0.232	0	1
Garage	0.655	0.475	0	1
One Car Garage	0.168	0.374	0	1
Multiple Car Garage	0.563	0.496	0	1
Within 1 Mile Parkway/Interstate	0.478	0.50	0	1
Within 1 Mile Railroad	0.509	0.50	0	1

[a] List and sales prices were converted to average 2011 dollars using the CPI.

[b] Residual from a sales price regression on housing characteristics, time, and location.

[c] The lot dimensions indicated the lot size was less than or greater than the listed value.

Table A2.2: Comparison of Transaction and House Characteristics for Listings of Large Independent, Small Independent, and Franchised Listing Brokers. Central Kentucky Data, 2000-2011.

	Means		
Variable	Large Independent	Small Independent	Franchised
Transaction			
List Price (2011 Dollars)	218,011	184,513	186,747
Sold Own Listing	0.412	0.351	0.349
Sold by Franchise	0.283	0.241	0.578
Sales Price (2011 Dollars)	208,855	176,715	179,317
Days on Market	81.425	86.655	83.808
% Out of State 5 Years Ago	9.602	8.621	9.126
% Out of State 1 Year Ago	12.042	10.004	10.828
5 Miles Ft. Knox	0.044	0.087	0.118
Degree Overpricing	0.037	-0.005	-0.007
# of Selling Agents in Listing Firm	467.654	12.756	60.651
House			
Bedrooms	3.312	3.203	3.252
Full Bathrooms	1.873	1.788	1.816
Partial Bathrooms	0.414	0.352	0.364
Square Feet of Living Space	1750	1627	1647
Lotsize (Acres)	0.747	0.82	0.901
Lotsize Missing	0.055	0.042	0.046
Has $<$ in Lot Dimensions	0.188	0.109	0.116
Has $>$ in Lot Dimensions	0.005	0.002	0.004
Age (Years)	35.461	32.684	32.369
Age Unknown	0.006	0.011	0.012
Fireplace	0.578	0.439	0.478
Basement	0.667	0.577	0.600
Finished Basement	0.220	0.142	0.190
Central Air	0.938	0.900	0.905
Brick Exterior	0.366	0.330	0.352
Vinyl Exterior	0.125	0.173	0.176
Metal Roof	0.009	0.011	0.010
Composition Roof	0.940	0.945	0.932
Ranch Style	0.413	0.458	0.454
Modular Style	0.005	0.017	0.016
Cape Cod Style	0.089	0.087	0.078
Carport	0.063	0.055	0.058
Garage	0.729	0.644	0.641
One Car Garage	0.175	0.164	0.169
Multiple Car Garage	0.592	0.549	0.567
Within 1 Mile Parkway/Interstate	0.543	0.465	0.470
Within 1 Mile Railroad	0.511	0.506	0.511

Table A2.3: Franchised Real Estate Broker Results from OLS Regressions for List Price and Sale of Own Listing. Central Kentucky Data, 2000-2011. Full Output.

VARIABLES	(1) ln(List Price)	(2) ln(List Price)	(3) Sold Own Listing	(4) Sold Own Listing
Listed by Franchise	-0.0128***		-0.0206***	
	(0.00143)		(0.00256)	
# of Selling Agents in the Listing Firm			0.000173***	0.000175***
			(8.48e-06)	(8.49e-06)
Listed by RE/MAX		-0.0158***		-0.0116***
		(0.00171)		(0.00302)
Listed by Coldwell Banker		-0.00494**		-0.0303***
		(0.00245)		(0.00467)
Listed by Century 21		-0.0280***		-0.0452***
		(0.00275)		(0.00476)
Listed by Keller Williams		0.0682***		0.0109
		(0.00532)		(0.00968)
Bedrooms	0.0154***	0.0152***	-0.0180***	-0.0181***
	(0.00155)	(0.00155)	(0.00225)	(0.00225)
Full Bathrooms	0.0950***	0.0950***	-0.00267	-0.00262
	(0.00179)	(0.00179)	(0.00290)	(0.00290)
Partial Bathrooms	0.0481***	0.0482***	-0.00626**	-0.00631**
	(0.00174)	(0.00174)	(0.00307)	(0.00307)
Square Feet of Living Space	0.000406***	0.000406***	-1.08e-05	-1.15e-05
	(6.50e-06)	(6.50e-06)	(7.80e-06)	(7.79e-06)
Square Feet^2	-1.81e-08***	-1.80e-08***	4.72e-09***	4.79e-09***
	(1.24e-09)	(1.24e-09)	(1.29e-09)	(1.29e-09)
Lotsize (Acres)	0.0208***	0.0208***	0.000953*	0.000963*
	(0.00113)	(0.00113)	(0.000500)	(0.000500)
Lotsize^2	-6.14e-05***	-6.15e-05***	-5.29e-06**	-5.37e-06**
	(8.97e-06)	(8.99e-06)	(2.38e-06)	(2.39e-06)
Lotsize Missing	-0.0112***	-0.0108***	0.0102*	0.00982
	(0.00292)	(0.00293)	(0.00616)	(0.00616)
Has $<$ in Lot Dimensions	-0.0216***	-0.0200***	-0.00725*	-0.00615
	(0.00207)	(0.00207)	(0.00392)	(0.00393)
Has $>$ in Lot Dimensions	0.00924	0.00918	0.0301	0.0316
	(0.0107)	(0.0107)	(0.0218)	(0.0218)
Age (Years)	-0.00594***	-0.00593***	-0.000548***	-0.000535***
	(0.000120)	(0.000120)	(0.000167)	(0.000167)
Age^2	1.89e-05***	1.88e-05***	8.88e-06***	8.81e-06***
	(1.36e-06)	(1.36e-06)	(1.56e-06)	(1.56e-06)
Age Unknown	-0.119***	-0.119***	0.0648***	0.0647***
	(0.0111)	(0.0111)	(0.0129)	(0.0129)

Table A2.3 (continued)

VARIABLES	(1) ln(List Price)	(2) ln(List Price)	(3) Sold Own Listing	(4) Sold Own Listing
Fireplace	0.0499***	0.0497***	-0.00709**	-0.00693**
	(0.00174)	(0.00174)	(0.00310)	(0.00310)
Basement	0.146***	0.146***	-0.00394	-0.00377
	(0.00190)	(0.00190)	(0.00321)	(0.00320)
Finished Basement	0.0369***	0.0367***	-0.0118***	-0.0122***
	(0.00182)	(0.00182)	(0.00377)	(0.00377)
Central Air	0.240***	0.239***	-0.0281***	-0.0275***
	(0.00401)	(0.00401)	(0.00463)	(0.00463)
Brick Exterior	0.0381***	0.0381***	0.000967	0.000712
	(0.00145)	(0.00145)	(0.00289)	(0.00289)
Vinyl Exterior	-0.0247***	-0.0244***	-0.00823**	-0.00858**
	(0.00262)	(0.00261)	(0.00383)	(0.00383)
Metal Roof	-0.00200	-0.00189	0.0306**	0.0306**
	(0.0124)	(0.0124)	(0.0138)	(0.0138)
Composition Roof	0.0210***	0.0209***	-0.0135**	-0.0133**
	(0.00395)	(0.00395)	(0.00612)	(0.00612)
Ranch Style	0.0591***	0.0591***	-0.0133***	-0.0133***
	(0.00196)	(0.00195)	(0.00332)	(0.00332)
Modular Style	-0.445***	-0.444***	0.101***	0.101***
	(0.00932)	(0.00933)	(0.0117)	(0.0118)
Cape Cod Style	0.0437***	0.0433***	-0.0191***	-0.0191***
	(0.00283)	(0.00282)	(0.00482)	(0.00482)
Carport	0.0145***	0.0144***	0.0126**	0.0122**
	(0.00340)	(0.00339)	(0.00613)	(0.00613)
Garage	0.0111***	0.0112***	0.00819*	0.00758*
	(0.00293)	(0.00293)	(0.00452)	(0.00452)
One Car Garage	0.0831***	0.0830***	-0.0130**	-0.0126**
	(0.00335)	(0.00335)	(0.00527)	(0.00526)
Multiple Car Garage	0.138***	0.138***	1.15e-05	0.000477
	(0.00311)	(0.00311)	(0.00493)	(0.00493)
Within 1 Mile Parkway/Interstate	-0.0285***	-0.0286***	-0.00956**	-0.00967**
	(0.00235)	(0.00235)	(0.00449)	(0.00448)
Within 1 Mile Railroad	-0.0136***	-0.0137***	0.00583	0.00577
	(0.00225)	(0.00225)	(0.00427)	(0.00427)
5 Miles Ft. Knox	-0.00154	-0.00157	-0.0233*	-0.0234*
	(0.00622)	(0.00622)	(0.0122)	(0.0122)
Constant	10.63***	10.63***	0.535***	0.532***
	(0.144)	(0.144)	(0.164)	(0.164)
Observations	145,851	145,851	145,851	145,851
R-squared	0.861	0.861	0.067	0.067
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes

Table A2.4: Franchised Real Estate Broker Results from OLS Regressions for List Price and Sale of Own Listing With Only Small Independent Brokers in the Omitted Category. Central Kentucky Data, 2000-2011

VARIABLES[a]	(1) ln(List Price)	(2) ln(List Price)	(3) Sold Own Listing	(4) Sold Own Listing
Listed by Franchise	-0.00153		-0.00868***	
	(0.00157)[a]		(0.00315)	
Listed by RE/MAX		-0.00436**		-0.00210
		(0.00184)		(0.00344)
Listed by Coldwell Banker		0.00572**		-0.0183***
		(0.00252)		(0.00512)
Listed by Century 21		-0.0169***		-0.0325***
		(0.00282)		(0.00526)
Listed by Keller Williams		0.0790***		0.0228**
		(0.00536)		(0.00990)
Listed by Largest Indep.	0.0440***	0.0438***	0.101***	0.0905***
	(0.00192)	(0.00192)	(0.0158)	(0.0160)
# of Selling Agents in Listing Firm			-3.82e-05	-1.42e-05
			(3.42e-05)	(3.45e-05)
Constant	10.62***	10.62***	0.535***	0.532***
	(0.144)	(0.145)	(0.163)	(0.163)
Observations	145,851	145,851	145,851	145,851
R-squared	0.861	0.862	0.067	0.067
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] Robust Standard Errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A2.5: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers. Central Kentucky Data, 2000-2011. Full Output.

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Franchise	-0.0132***	-3.642***	-0.00368**	-3.621***
	(0.00156)	(0.436)	(0.00172)	(0.478)
Sold by Franchise	0.00186	-0.934**	0.00831***	-1.131**
	(0.00154)	(0.442)	(0.00170)	(0.482)
Listed by Largest Indep.			0.0387***	0.0129
			(0.00208)	(0.634)
Sold by Largest Indep.			0.0263***	-0.721
			(0.00204)	(0.591)
Degree Overpricing		31.23***		31.26***
		(0.857)		(0.860)
Bedrooms	0.0199***	-1.483***	0.0198***	-1.482***
	(0.00166)	(0.393)	(0.00165)	(0.393)
Full Bathrooms	0.0935***	-0.588	0.0932***	-0.586
	(0.00189)	(0.521)	(0.00189)	(0.521)
Partial Bathrooms	0.0484***	-1.116**	0.0481***	-1.114**
	(0.00182)	(0.534)	(0.00182)	(0.534)
Square Feet of Living Space	0.000417***	0.00889***	0.000417***	0.00890***
	(6.56e-06)	(0.00158)	(6.56e-06)	(0.00158)
Square Feet^2	-2.15e-08***	5.82e-07**	-2.14e-08***	5.80e-07**
	(1.23e-09)	(2.94e-07)	(1.23e-09)	(2.94e-07)
Lotsize (Acres)	0.0199***	0.488***	0.0198***	0.488***
	(0.00107)	(0.144)	(0.00107)	(0.144)
Lotsize^2	-5.83e-05***	-0.00201***	-5.80e-05***	-0.00201***
	(8.38e-06)	(0.000682)	(8.35e-06)	(0.000682)
Lotsize Missing	-0.00983***	1.296	-0.0109***	1.302
	(0.00311)	(1.003)	(0.00311)	(1.003)
Has $<$ in Lot Dimensions	-0.0208***	-3.495***	-0.0237***	-3.480***
	(0.00226)	(0.556)	(0.00225)	(0.556)
Has $>$ in Lot Dimensions	0.00863	2.601	0.00446	2.633
	(0.0115)	(3.426)	(0.0115)	(3.426)
Age (Years)	-0.00650***	-0.495***	-0.00656***	-0.494***
	(0.000128)	(0.0336)	(0.000128)	(0.0336)
Age^2	1.92e-05***	0.00372***	1.97e-05***	0.00372***
	(1.46e-06)	(0.000331)	(1.45e-06)	(0.000331)
Age Unknown	-0.134***	15.17***	-0.133***	15.15***
	(0.0122)	(2.924)	(0.0122)	(2.924)

Table A2.5 (continued)

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Fireplace	0.0493***	3.936***	0.0477***	3.945***
	(0.00185)	(0.533)	(0.00185)	(0.534)
Basement	0.151***	0.829	0.151***	0.827
	(0.00205)	(0.551)	(0.00205)	(0.551)
Finished Basement	0.0347***	-1.823***	0.0335***	-1.810***
	(0.00192)	(0.627)	(0.00192)	(0.627)
Central Air	0.266***	7.489***	0.264***	7.509***
	(0.00435)	(0.757)	(0.00434)	(0.758)
Brick Exterior	0.0410***	-1.238**	0.0409***	-1.238**
	(0.00154)	(0.492)	(0.00154)	(0.492)
Vinyl Exterior	-0.0188***	-2.942***	-0.0188***	-2.943***
	(0.00286)	(0.675)	(0.00285)	(0.675)
Metal Roof	-0.0105	5.320*	-0.0126	5.348*
	(0.0133)	(2.812)	(0.0133)	(2.812)
Composition Roof	0.0176***	2.037*	0.0171***	2.048*
	(0.00420)	(1.096)	(0.00420)	(1.096)
Ranch Style	0.0618***	-3.542***	0.0615***	-3.541***
	(0.00210)	(0.579)	(0.00210)	(0.579)
Modular Style	-0.480***	-1.745	-0.478***	-1.757
	(0.0103)	(2.493)	(0.0102)	(2.493)
Cape Cod Style	0.0471***	-2.647***	0.0469***	-2.644***
	(0.00304)	(0.810)	(0.00304)	(0.810)
Carport	0.0154***	-1.957*	0.0147***	-1.955*
	(0.00366)	(1.013)	(0.00365)	(1.013)
Garage	0.00865***	-9.152***	0.00815**	-9.148***
	(0.00319)	(0.829)	(0.00318)	(0.829)
One Car Garage	0.0911***	7.262***	0.0913***	7.260***
	(0.00364)	(0.937)	(0.00363)	(0.937)
Multiple Car Garage	0.144***	7.110***	0.144***	7.106***
	(0.00336)	(0.915)	(0.00335)	(0.915)
Within 1 Mile Parkway/Interstate	-0.0291***	-4.932***	-0.0291***	-4.933***
	(0.00251)	(0.764)	(0.00251)	(0.764)
Within 1 Mile Railroad	-0.0153***	0.343	-0.0153***	0.340
	(0.00238)	(0.782)	(0.00238)	(0.782)
5 Miles Ft. Knox	-0.000438	-5.353**	-0.00104	-5.357**
	(0.00666)	(2.538)	(0.00662)	(2.539)
Constant	10.56***	150.5***	10.55***	150.4***
	(0.143)	(29.19)	(0.143)	(29.19)
Observations	145,851	145,851	145,851	145,851
R-squared	0.851	0.106	0.852	0.106
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

Table A2.6: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers with Agent Fixed Effects Specification 1. Central Kentucky Data, 2000-2011. Full Output.

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Franchise	0.0306***	3.020***	0.0396***	3.017***
	(0.00271)	(0.677)	(0.00278)	(0.705)
Sold by Franchise	0.00184	-0.935**	0.00837***	-1.116**
	(0.00154)	(0.442)	(0.00170)	(0.482)
Listing Agent has, is, or will be Affiliated with a Franchise	-0.0545***	-8.305***	-0.0541***	-8.303***
	(0.00266)	(0.672)	(0.00264)	(0.672)
Listed by Largest Indep.			0.0380***	-0.0650
			(0.00208)	(0.634)
Sold by Largest Indep.			0.0266***	-0.670
			(0.00203)	(0.590)
Degree Overpricing		30.62***		30.66***
		(0.860)		(0.862)
Bedrooms	0.0198***	-1.489***	0.0198***	-1.488***
	(0.00165)	(0.393)	(0.00165)	(0.393)
Full Bathrooms	0.0934***	-0.603	0.0931***	-0.600
	(0.00189)	(0.521)	(0.00189)	(0.521)
Partial Bathrooms	0.0483***	-1.132**	0.0480***	-1.130**
	(0.00182)	(0.534)	(0.00182)	(0.534)
Square Feet of Living Space	0.000416***	0.00877***	0.000416***	0.00877***
	(6.56e-06)	(0.00158)	(6.56e-06)	(0.00158)
Square Feet^2	-2.14e-08***	5.97e-07**	-2.13e-08***	5.96e-07**
	(1.23e-09)	(2.94e-07)	(1.23e-09)	(2.94e-07)
Lotsize (Acres)	0.0199***	0.488***	0.0198***	0.488***
	(0.00107)	(0.144)	(0.00107)	(0.144)
Lotsize^2	-5.82e-05***	-0.00200***	-5.80e-05***	-0.00200***
	(8.39e-06)	(0.000678)	(8.35e-06)	(0.000678)
Lotsize Missing	-0.00898***	1.426	-0.00999***	1.433
	(0.00311)	(1.002)	(0.00311)	(1.002)
Has $<$ in Lot Dimensions	-0.0209***	-3.517***	-0.0238***	-3.499***
	(0.00226)	(0.555)	(0.00225)	(0.556)
Has $>$ in Lot Dimensions	0.00987	2.790	0.00573	2.825
	(0.0114)	(3.420)	(0.0114)	(3.420)
Age (Years)	-0.00649***	-0.493***	-0.00654***	-0.493***
	(0.000128)	(0.0335)	(0.000128)	(0.0336)
Age^2	1.91e-05***	0.00370***	1.96e-05***	0.00370***
	(1.46e-06)	(0.000331)	(1.45e-06)	(0.000331)
Age Unknown	-0.133***	15.35***	-0.132***	15.34***
	(0.0122)	(2.921)	(0.0122)	(2.921)

Table A2.6 (continued)

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Fireplace	0.0495***	3.957***	0.0479***	3.968***
	(0.00185)	(0.533)	(0.00185)	(0.534)
Basement	0.151***	0.817	0.151***	0.816
	(0.00205)	(0.551)	(0.00204)	(0.551)
Finished Basement	0.0347***	-1.832***	0.0334***	-1.817***
	(0.00192)	(0.627)	(0.00192)	(0.627)
Central Air	0.267***	7.659***	0.265***	7.679***
	(0.00435)	(0.757)	(0.00434)	(0.757)
Brick Exterior	0.0415***	-1.165**	0.0414***	-1.164**
	(0.00154)	(0.492)	(0.00154)	(0.492)
Vinyl Exterior	-0.0187***	-2.921***	-0.0186***	-2.922***
	(0.00285)	(0.675)	(0.00284)	(0.675)
Metal Roof	-0.0104	5.333*	-0.0125	5.361*
	(0.0133)	(2.814)	(0.0133)	(2.813)
Composition Roof	0.0180***	2.100*	0.0175***	2.111*
	(0.00420)	(1.096)	(0.00420)	(1.096)
Ranch Style	0.0616***	-3.569***	0.0613***	-3.568***
	(0.00210)	(0.579)	(0.00210)	(0.579)
Modular Style	-0.480***	-1.776	-0.478***	-1.790
	(0.0103)	(2.492)	(0.0102)	(2.492)
Cape Cod Style	0.0471***	-2.649***	0.0469***	-2.646***
	(0.00304)	(0.809)	(0.00303)	(0.809)
Carport	0.0154***	-1.959*	0.0147***	-1.955*
	(0.00365)	(1.013)	(0.00364)	(1.012)
Garage	0.00903***	-9.095***	0.00852***	-9.091***
	(0.00318)	(0.829)	(0.00317)	(0.829)
One Car Garage	0.0908***	7.215***	0.0909***	7.213***
	(0.00363)	(0.937)	(0.00362)	(0.937)
Multiple Car Garage	0.144***	7.061***	0.144***	7.057***
	(0.00335)	(0.915)	(0.00334)	(0.915)
Within 1 Mile Parkway/Interstate	-0.0294***	-4.974***	-0.0293***	-4.975***
	(0.00250)	(0.763)	(0.00250)	(0.763)
Within 1 Mile Railroad	-0.0155***	0.315	-0.0155***	0.313
	(0.00238)	(0.782)	(0.00238)	(0.782)
5 Miles Ft. Knox	0.000443	-5.219**	-0.000152	-5.221**
	(0.00666)	(2.540)	(0.00662)	(2.540)
Constant	10.58***	153.7***	10.58***	153.6***
	(0.144)	(29.01)	(0.144)	(29.01)
Observations	145,851	145,851	145,851	145,851
R-squared	0.852	0.107	0.852	0.107
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

Table A2.7: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers using Franchised Listing Agent Fixed Effects Specification 2. Central Kentucky Data, 2000-2011. Full Output.

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Franchise	0.00575	-1.767	0.0142***	-1.656
	(0.00367)	(1.145)	(0.00371)	(1.165)
Sold by Franchise	0.00140	-1.242***	0.00593***	-1.522***
	(0.00147)	(0.443)	(0.00162)	(0.484)
Listed by Largest Indep.			0.0338***	0.363
			(0.00215)	(0.680)
Sold by Largest Indep.			0.0183***	-0.995*
			(0.00196)	(0.589)
Degree Overpricing		24.50***		24.51***
		(0.915)		(0.916)
Bedrooms	0.0191***	-1.492***	0.0191***	-1.491***
	(0.00158)	(0.392)	(0.00158)	(0.392)
Full Bathrooms	0.0904***	-0.553	0.0901***	-0.553
	(0.00182)	(0.519)	(0.00182)	(0.519)
Partial Bathrooms	0.0469***	-1.113**	0.0467***	-1.113**
	(0.00176)	(0.531)	(0.00175)	(0.531)
Square Feet of Living Space	0.000407***	0.00922***	0.000406***	0.00923***
	(6.40e-06)	(0.00157)	(6.39e-06)	(0.00157)
Square Feet^2	-2.00e-08***	5.12e-07*	-2.00e-08***	5.11e-07*
	(1.20e-09)	(2.93e-07)	(1.20e-09)	(2.93e-07)
Lotsize (Acres)	0.0197***	0.483***	0.0197***	0.483***
	(0.00111)	(0.144)	(0.00111)	(0.144)
Lotsize^2	-5.96e-05***	-0.00191***	-5.95e-05***	-0.00191***
	(8.63e-06)	(0.000643)	(8.59e-06)	(0.000642)
Lotsize Missing	-0.0107***	2.238**	-0.0114***	2.237**
	(0.00303)	(1.005)	(0.00303)	(1.005)
Has $<$ in Lot Dimensions	-0.0106***	-2.040***	-0.0130***	-2.041***
	(0.00218)	(0.577)	(0.00218)	(0.577)
Has $>$ in Lot Dimensions	0.0168	2.787	0.0132	2.807
	(0.0113)	(3.440)	(0.0113)	(3.440)
Age (Years)	-0.00632***	-0.437***	-0.00637***	-0.438***
	(0.000126)	(0.0339)	(0.000125)	(0.0339)
Age^2	1.86e-05***	0.00334***	1.90e-05***	0.00334***
	(1.41e-06)	(0.000335)	(1.41e-06)	(0.000335)
Age Unknown	-0.136***	14.56***	-0.135***	14.54***
	(0.0117)	(2.938)	(0.0117)	(2.938)

Table A2.7 (continued)

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Fireplace	0.0444***	3.057***	0.0431***	3.057***
	(0.00179)	(0.539)	(0.00178)	(0.539)
Basement	0.152***	0.891	0.152***	0.891
	(0.00196)	(0.549)	(0.00196)	(0.549)
Finished Basement	0.0252***	-1.752***	0.0243***	-1.741***
	(0.00189)	(0.630)	(0.00189)	(0.630)
Central Air	0.247***	6.810***	0.245***	6.823***
	(0.00428)	(0.789)	(0.00427)	(0.789)
Brick Exterior	0.0409***	-1.505***	0.0408***	-1.506***
	(0.00152)	(0.500)	(0.00152)	(0.500)
Vinyl Exterior	-0.0142***	-2.459***	-0.0142***	-2.461***
	(0.00272)	(0.674)	(0.00272)	(0.674)
Metal Roof	-0.0333**	4.080	-0.0351***	4.100
	(0.0130)	(2.833)	(0.0130)	(2.833)
Composition Roof	0.0126***	1.288	0.0120***	1.296
	(0.00421)	(1.144)	(0.00420)	(1.144)
Ranch Style	0.0584***	-3.706***	0.0581***	-3.709***
	(0.00204)	(0.585)	(0.00204)	(0.585)
Modular Style	-0.472***	-1.246	-0.471***	-1.255
	(0.0102)	(2.502)	(0.0101)	(2.502)
Cape Cod Style	0.0402***	-3.391***	0.0401***	-3.388***
	(0.00292)	(0.813)	(0.00291)	(0.813)
Carport	0.00465	-0.525	0.00404	-0.524
	(0.00352)	(1.022)	(0.00351)	(1.021)
Garage	0.00200	-5.232***	0.00131	-5.226***
	(0.00321)	(0.867)	(0.00320)	(0.866)
One Car Garage	0.0902***	4.580***	0.0905***	4.575***
	(0.00355)	(0.960)	(0.00354)	(0.960)
Multiple Car Garage	0.142***	4.420***	0.142***	4.412***
	(0.00329)	(0.938)	(0.00328)	(0.938)
Within 1 Mile Parkway/Interstate	-0.0302***	-4.742***	-0.0302***	-4.744***
	(0.00243)	(0.764)	(0.00243)	(0.764)
Within 1 Mile Railroad	-0.0161***	0.408	-0.0161***	0.403
	(0.00233)	(0.778)	(0.00232)	(0.778)
5 Miles Ft. Knox	0.0117*	-3.127	0.0110*	-3.133
	(0.00660)	(2.552)	(0.00657)	(2.552)
Constant	10.59***	144.6***	10.59***	144.5***
	(0.123)	(30.07)	(0.123)	(30.06)
Observations	145,851	145,851	145,851	145,851
R-squared	0.869	0.144	0.869	0.144
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	Yes	Yes	Yes	Yes

Table A2.8: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers. Separate Firm Intercepts. Central Kentucky Data, 2000-2011. Full Output.

	(1)	(2)	(3)	(4)
VARIABLES	ln(Sold Price)	Days On Market	ln(Sold Price)	Days On Market
Listed by Century 21	-0.0306***	-3.041***	-0.0211***	-3.011***
	(0.00300)	(0.829)	(0.00308)	(0.852)
Sold by Century 21	1.20e-06	-0.755	0.00603**	-0.943
	(0.00292)	(0.865)	(0.00300)	(0.886)
Listed by Coldwell Banker	-0.00664**	-5.516***	0.00208	-5.477***
	(0.00273)	(0.799)	(0.00281)	(0.823)
Sold by Coldwell Banker	-0.00117	-1.399*	0.00504*	-1.589*
	(0.00287)	(0.827)	(0.00295)	(0.849)
Listed by Keller Williams	0.0654***	-19.07***	0.0744***	-19.04***
	(0.00585)	(1.472)	(0.00589)	(1.482)
Sold by Keller Williams	0.0392***	-0.803	0.0459***	-0.996
	(0.00548)	(1.414)	(0.00552)	(1.426)
Listed by RE/MAX	-0.0143***	-2.197***	-0.00458**	-2.167***
	(0.00185)	(0.508)	(0.00199)	(0.544)
Sold by RE/MAX	-0.000196	-0.902*	0.00641***	-1.099*
	(0.00181)	(0.532)	(0.00195)	(0.567)
Listed by Largest Indep.			0.0386***	0.0553
			(0.00208)	(0.634)
Sold by Largest Indep.			0.0262***	-0.707
			(0.00203)	(0.591)
Degree Overpricing		31.52***		31.55***
		(0.859)		(0.862)
Bedrooms	0.0196***	-1.438***	0.0195***	-1.437***
	(0.00166)	(0.393)	(0.00165)	(0.393)
Full Bathrooms	0.0935***	-0.587	0.0932***	-0.585
	(0.00189)	(0.521)	(0.00189)	(0.521)
Partial Bathrooms	0.0484***	-1.121**	0.0481***	-1.120**
	(0.00182)	(0.534)	(0.00182)	(0.534)
Square Feet of Living Space	0.000417***	0.00885***	0.000417***	0.00886***
	(6.56e-06)	(0.00158)	(6.55e-06)	(0.00158)
Square Feet^2	-2.14e-08***	5.76e-07*	-2.13e-08***	5.74e-07*
	(1.23e-09)	(2.94e-07)	(1.23e-09)	(2.94e-07)
Lotsize (Acres)	0.0199***	0.486***	0.0198***	0.486***
	(0.00107)	(0.143)	(0.00107)	(0.143)
Lotsize^2	-5.83e-05***	-0.00201***	-5.80e-05***	-0.00201***
	(8.41e-06)	(0.000678)	(8.37e-06)	(0.000678)
Lotsize Missing	-0.00947***	1.200	-0.0105***	1.204
	(0.00311)	(1.003)	(0.00311)	(1.004)
Has $<$ in Lot Dimensions	-0.0191***	-3.692***	-0.0220***	-3.680***
	(0.00226)	(0.558)	(0.00225)	(0.558)
Has $>$ in Lot Dimensions	0.00904	2.714	0.00495	2.741
	(0.0115)	(3.425)	(0.0115)	(3.425)
Age (Years)	-0.00649***	-0.495***	-0.00654***	-0.494***
	(0.000128)	(0.0335)	(0.000128)	(0.0335)
Age^2	1.91e-05***	0.00373***	1.95e-05***	0.00373***
	(1.46e-06)	(0.000330)	(1.45e-06)	(0.000331)

Table A2.8 (continued)

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Age Unknown	-0.134***	15.00***	-0.133***	14.99***
	(0.0122)	(2.925)	(0.0122)	(2.924)
Fireplace	0.0491***	3.993***	0.0475***	4.001***
	(0.00185)	(0.534)	(0.00185)	(0.534)
Basement	0.152***	0.790	0.152***	0.789
	(0.00205)	(0.551)	(0.00205)	(0.551)
Finished Basement	0.0345***	-1.802***	0.0332***	-1.789***
	(0.00192)	(0.627)	(0.00192)	(0.627)
Central Air	0.265***	7.681***	0.263***	7.698***
	(0.00435)	(0.759)	(0.00434)	(0.759)
Brick Exterior	0.0410***	-1.270***	0.0409***	-1.270***
	(0.00154)	(0.492)	(0.00154)	(0.492)
Vinyl Exterior	-0.0185***	-3.034***	-0.0185***	-3.035***
	(0.00285)	(0.675)	(0.00284)	(0.675)
Metal Roof	-0.0103	5.296*	-0.0124	5.322*
	(0.0133)	(2.810)	(0.0133)	(2.809)
Composition Roof	0.0177***	2.058*	0.0172***	2.068*
	(0.00420)	(1.096)	(0.00419)	(1.096)
Ranch Style	0.0619***	-3.558***	0.0615***	-3.558***
	(0.00210)	(0.579)	(0.00210)	(0.579)
Modular Style	-0.479***	-1.845	-0.477***	-1.856
	(0.0103)	(2.493)	(0.0102)	(2.493)
Cape Cod Style	0.0467***	-2.569***	0.0465***	-2.566***
	(0.00304)	(0.809)	(0.00303)	(0.809)
Carport	0.0153***	-1.969*	0.0146***	-1.967*
	(0.00366)	(1.013)	(0.00365)	(1.012)
Garage	0.00877***	-9.259***	0.00825***	-9.255***
	(0.00319)	(0.829)	(0.00318)	(0.829)
One Car Garage	0.0911***	7.314***	0.0913***	7.312***
	(0.00364)	(0.936)	(0.00362)	(0.936)
Multiple Car Garage	0.144***	7.196***	0.144***	7.192***
	(0.00336)	(0.915)	(0.00335)	(0.915)
Within 1 Mile Parkway/Interstate	-0.0292***	-4.918***	-0.0292***	-4.919***
	(0.00250)	(0.764)	(0.00251)	(0.764)
Within 1 Mile Railroad	-0.0155***	0.364	-0.0155***	0.361
	(0.00238)	(0.781)	(0.00238)	(0.781)
5 Miles Ft. Knox	-0.000456	-5.352**	-0.00105	-5.356**
	(0.00667)	(2.536)	(0.00663)	(2.536)
Constant	10.56***	149.5***	10.56***	149.5***
	(0.143)	(29.25)	(0.143)	(29.25)
Observations	145,851	145,851	145,851	145,851
R-squared	0.852	0.107	0.852	0.107
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

Table A2.9: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers with Agent Fixed Effects Specification 1. Separate Firm Intercepts. Central Kentucky Data, 2000-2011. Full Output.

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Listed by Century 21	0.0130***	3.648***	0.0220***	3.654***
	(0.00373)	(0.976)	(0.00378)	(0.996)
Sold by Century 21	0.000338	-0.703	0.00644**	-0.875
	(0.00291)	(0.864)	(0.00299)	(0.886)
Listed by Coldwell Banker	0.0363***	1.091	0.0445***	1.107
	(0.00348)	(0.957)	(0.00353)	(0.978)
Sold by Coldwell Banker	-0.00131	-1.419*	0.00499*	-1.594*
	(0.00286)	(0.826)	(0.00295)	(0.848)
Listed by Keller Williams	0.109***	-12.38***	0.117***	-12.38***
	(0.00626)	(1.559)	(0.00629)	(1.569)
Sold by Keller Williams	0.0389***	-0.834	0.0457***	-1.012
	(0.00547)	(1.413)	(0.00551)	(1.426)
Listed by RE/MAX	0.0294***	4.529***	0.0387***	4.535***
	(0.00289)	(0.722)	(0.00297)	(0.749)
Sold by RE/MAX	-0.000238	-0.908*	0.00645***	-1.090*
	(0.00181)	(0.532)	(0.00195)	(0.566)
Listing Agent has, is, or will be Affiliated with a Franchise[c]	-0.0542***	-8.349***	-0.0538***	-8.346***
	(0.00266)	(0.672)	(0.00264)	(0.672)
Listed by Largest Indep.			0.0380***	-0.0222
			(0.00208)	(0.633)
Sold by Largest Indep.			0.0265***	-0.656
			(0.00203)	(0.590)
Bedrooms	0.0195***	-1.443***	0.0195***	-1.442***
	(0.00165)	(0.393)	(0.00165)	(0.393)
Full Bathrooms	0.0934***	-0.601	0.0931***	-0.599
	(0.00189)	(0.521)	(0.00188)	(0.521)
Partial Bathrooms	0.0483***	-1.137**	0.0480***	-1.135**
	(0.00182)	(0.533)	(0.00182)	(0.533)
Square Feet of Living Space	0.000416***	0.00872***	0.000416***	0.00873***
	(6.56e-06)	(0.00158)	(6.56e-06)	(0.00158)
Square Feet^2	-2.13e-08***	5.91e-07**	-2.12e-08***	5.90e-07**
	(1.23e-09)	(2.94e-07)	(1.23e-09)	(2.94e-07)
Lotsize (Acres)	0.0199***	0.486***	0.0198***	0.486***
	(0.00107)	(0.143)	(0.00107)	(0.143)
Lotsize^2	-5.82e-05***	-0.00200***	-5.80e-05***	-0.00200***
	(8.41e-06)	(0.000674)	(8.37e-06)	(0.000674)
Lotsize Missing	-0.00864***	1.328	-0.00967***	1.334
	(0.00311)	(1.003)	(0.00311)	(1.003)
Has $<$ in Lot Dimensions	-0.0193***	-3.718***	-0.0222***	-3.702***
	(0.00226)	(0.558)	(0.00225)	(0.558)
Has $>$ in Lot Dimensions	0.0103	2.911	0.00625	2.941
	(0.0114)	(3.419)	(0.0114)	(3.419)
Age (Years)	-0.00648***	-0.493***	-0.00653***	-0.493***
	(0.000128)	(0.0335)	(0.000128)	(0.0335)
Age^2	1.90e-05***	0.00371***	1.94e-05***	0.00371***
	(1.46e-06)	(0.000330)	(1.45e-06)	(0.000331)

Table A2.9 (continued)

VARIABLES[a]	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Age Unknown	-0.132***	15.18***	-0.132***	15.17***
	(0.0122)	(2.922)	(0.0122)	(2.921)
Fireplace	0.0492***	4.016***	0.0477***	4.025***
	(0.00185)	(0.533)	(0.00185)	(0.534)
Basement	0.152***	0.779	0.152***	0.778
	(0.00205)	(0.551)	(0.00204)	(0.551)
Finished Basement	0.0344***	-1.810***	0.0332***	-1.797***
	(0.00192)	(0.627)	(0.00192)	(0.627)
Central Air	0.266***	7.855***	0.265***	7.873***
	(0.00435)	(0.759)	(0.00434)	(0.759)
Brick Exterior	0.0415***	-1.196**	0.0414***	-1.196**
	(0.00154)	(0.492)	(0.00154)	(0.492)
Vinyl Exterior	-0.0184***	-3.014***	-0.0184***	-3.015***
	(0.00285)	(0.675)	(0.00284)	(0.675)
Metal Roof	-0.0102	5.308*	-0.0123	5.335*
	(0.0133)	(2.811)	(0.0133)	(2.811)
Composition Roof	0.0181***	2.123*	0.0176***	2.133*
	(0.00420)	(1.096)	(0.00419)	(1.096)
Ranch Style	0.0617***	-3.586***	0.0613***	-3.585***
	(0.00210)	(0.579)	(0.00209)	(0.579)
Modular Style	-0.479***	-1.878	-0.477***	-1.890
	(0.0103)	(2.492)	(0.0102)	(2.493)
Cape Cod Style	0.0467***	-2.571***	0.0465***	-2.568***
	(0.00303)	(0.809)	(0.00303)	(0.809)
Carport	0.0153***	-1.970*	0.0146***	-1.967*
	(0.00365)	(1.012)	(0.00364)	(1.012)
Garage	0.00914***	-9.203***	0.00861***	-9.199***
	(0.00318)	(0.829)	(0.00317)	(0.829)
One Car Garage	0.0908***	7.267***	0.0910***	7.264***
	(0.00363)	(0.936)	(0.00362)	(0.936)
Multiple Car Garage	0.144***	7.147***	0.144***	7.143***
	(0.00335)	(0.915)	(0.00334)	(0.915)
Within 1 Mile Parkway/Interstate	-0.0295***	-4.960***	-0.0295***	-4.961***
	(0.00250)	(0.763)	(0.00250)	(0.763)
Within 1 Mile Railroad	-0.0157***	0.336	-0.0157***	0.334
	(0.00238)	(0.781)	(0.00238)	(0.781)
5 Miles Ft. Knox	0.000418	-5.217**	-0.000170	-5.220**
	(0.00667)	(2.537)	(0.00662)	(2.537)
Degree Overpricing		30.91***		30.95***
		(0.862)		(0.864)
Constant	10.58***	152.7***	10.58***	152.7***
	(0.144)	(29.08)	(0.144)	(29.08)
Observations	145,851	145,851	145,851	145,851
R-squared	0.852	0.107	0.853	0.107
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	No	No	No	No

Table A2.10: Regression Results for Comparison of Sales Price and Days on Market for Franchised and Independent Real Estate Brokers using Franchised Listing Agent Fixed Effects Specification 2. Separate Firm Intercepts. Central Kentucky Data, 2000-2011. Full Output.

	(1)	(2)	(3)	(4)
VARIABLES	ln(Sold Price)	Days On Market	ln(Sold Price)	Days On Market
Listed by Century 21	0.000471	5.053**	0.00588	5.164***
	(0.00713)	(1.993)	(0.00714)	(2.000)
Sold by Century 21	-0.00131	-0.970	0.00294	-1.238
	(0.00275)	(0.866)	(0.00282)	(0.888)
Listed by Coldwell Banker	-0.0186**	-11.16***	-0.0137*	-11.04***
	(0.00757)	(3.077)	(0.00757)	(3.082)
Sold by Coldwell Banker	-0.00381	-2.275***	0.000678	-2.545***
	(0.00272)	(0.828)	(0.00280)	(0.851)
Listed by Keller Williams	0.0296***	-6.729***	0.0437***	-6.627***
	(0.00811)	(2.281)	(0.00816)	(2.292)
Sold by Keller Williams	0.0316***	-1.375	0.0365***	-1.645
	(0.00523)	(1.410)	(0.00527)	(1.422)
Listed by RE/MAX	0.0119***	-0.0445	0.0222***	0.0501
	(0.00459)	(1.269)	(0.00462)	(1.287)
Sold by RE/MAX	0.000758	-0.970*	0.00544***	-1.251**
	(0.00173)	(0.531)	(0.00186)	(0.566)
Listed by Largest Indep.			0.0345***	0.341
			(0.00215)	(0.680)
Sold by Largest Indep.			0.0184***	-0.980*
			(0.00196)	(0.589)
Degree Overpricing		24.48***		24.49***
		(0.915)		(0.917)
Bedrooms	0.0190***	-1.495***	0.0191***	-1.494***
	(0.00158)	(0.392)	(0.00158)	(0.392)
Full Bathrooms	0.0904***	-0.533	0.0902***	-0.532
	(0.00182)	(0.519)	(0.00182)	(0.519)
Partial Bathrooms	0.0469***	-1.106**	0.0467***	-1.106**
	(0.00176)	(0.531)	(0.00175)	(0.531)
Square Feet of Living Space	0.000407***	0.00920***	0.000406***	0.00921***
	(6.40e-06)	(0.00157)	(6.39e-06)	(0.00157)
Square Feet^2	-2.00e-08***	5.13e-07*	-2.00e-08***	5.11e-07*
	(1.20e-09)	(2.93e-07)	(1.20e-09)	(2.93e-07)
Lotsize (Acres)	0.0197***	0.481***	0.0197***	0.481***
	(0.00111)	(0.144)	(0.00111)	(0.144)
Lotsize^2	-5.96e-05***	-0.00191***	-5.95e-05***	-0.00191***
	(8.65e-06)	(0.000647)	(8.62e-06)	(0.000647)
Lotsize Missing	-0.0109***	2.215**	-0.0116***	2.215**
	(0.00303)	(1.005)	(0.00303)	(1.005)
Has $<$ in Lot Dimensions	-0.0105***	-2.121***	-0.0130***	-2.121***
	(0.00218)	(0.577)	(0.00218)	(0.577)
Has $>$ in Lot Dimensions	0.0172	2.945	0.0136	2.966
	(0.0113)	(3.441)	(0.0113)	(3.440)
Age (Years)	-0.00632***	-0.437***	-0.00637***	-0.437***
	(0.000126)	(0.0339)	(0.000125)	(0.0339)

Table A2.10 (continued)

VARIABLES	(1) ln(Sold Price)	(2) Days On Market	(3) ln(Sold Price)	(4) Days On Market
Age^2	1.85e-05***	0.00334***	1.89e-05***	0.00334***
	(1.42e-06)	(0.000335)	(1.41e-06)	(0.000335)
Age Unknown	-0.136***	14.49***	-0.135***	14.48***
	(0.0117)	(2.938)	(0.0117)	(2.938)
Fireplace	0.0444***	3.052***	0.0431***	3.053***
	(0.00179)	(0.539)	(0.00178)	(0.539)
Basement	0.152***	0.898	0.152***	0.897
	(0.00196)	(0.549)	(0.00196)	(0.549)
Finished Basement	0.0252***	-1.750***	0.0244***	-1.739***
	(0.00189)	(0.630)	(0.00189)	(0.630)
Central Air	0.247***	6.830***	0.245***	6.843***
	(0.00428)	(0.789)	(0.00427)	(0.790)
Brick Exterior	0.0409***	-1.508***	0.0407***	-1.509***
	(0.00152)	(0.500)	(0.00152)	(0.500)
Vinyl Exterior	-0.0141***	-2.464***	-0.0141***	-2.466***
	(0.00272)	(0.674)	(0.00272)	(0.674)
Metal Roof	-0.0329**	4.199	-0.0348***	4.219
	(0.0130)	(2.832)	(0.0130)	(2.832)
Composition Roof	0.0129***	1.396	0.0122***	1.404
	(0.00421)	(1.144)	(0.00420)	(1.144)
Ranch Style	0.0584***	-3.740***	0.0581***	-3.743***
	(0.00204)	(0.585)	(0.00204)	(0.585)
Modular Style	-0.472***	-1.359	-0.471***	-1.368
	(0.0102)	(2.502)	(0.0101)	(2.502)
Cape Cod Style	0.0402***	-3.385***	0.0400***	-3.383***
	(0.00292)	(0.813)	(0.00291)	(0.813)
Carport	0.00465	-0.527	0.00402	-0.525
	(0.00352)	(1.022)	(0.00351)	(1.022)
Garage	0.00199	-5.252***	0.00128	-5.246***
	(0.00321)	(0.866)	(0.00320)	(0.866)
One Car Garage	0.0902***	4.586***	0.0905***	4.580***
	(0.00355)	(0.960)	(0.00354)	(0.960)
Multiple Car Garage	0.142***	4.433***	0.142***	4.426***
	(0.00329)	(0.937)	(0.00328)	(0.937)
Within 1 Mile Parkway/Interstate	-0.0302***	-4.743***	-0.0302***	-4.744***
	(0.00243)	(0.764)	(0.00243)	(0.764)
Within 1 Mile Railroad	-0.0162***	0.381	-0.0162***	0.377
	(0.00233)	(0.779)	(0.00232)	(0.779)
5 Miles Ft. Knox	0.0118*	-3.095	0.0110*	-3.102
	(0.00661)	(2.551)	(0.00658)	(2.552)
Constant	10.59***	144.8***	10.59***	144.7***
	(0.124)	(30.02)	(0.123)	(30.02)
Observations	145,851	145,851	145,851	145,851
R-squared	0.869	0.144	0.869	0.144
Year-Month Dummies	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	Yes
Franchise Listing Agent Fixed Effects	Yes	Yes	Yes	Yes

Table A2.11: Regression Results for Comparison of Out-of-state Movers for Franchised and Independent Real Estate Brokers. Central Kentucky Data, 2000-2011. Full Output.

VARIABLES	(1) Sold by Franchise	(2) Sold by Franchise	(3) Sold by Franchise
Listed by Franchise	0.308***	0.322***	0.322***
	(0.00256)	(0.00250)	(0.00250)
5 Miles Ft. Knox	0.0138		
	(0.0110)		
% Out of State 5 Years Ago		0.00226***	
		(0.000265)	
% Out of State 1 Year Ago			0.000315***
			(6.47e-05)
% Out of State (2010) Missing			-0.00187
			(0.104)
Bedrooms	0.00280	0.00480**	0.00453**
	(0.00214)	(0.00210)	(0.00210)
Full Bathrooms	0.000470	-0.000219	0.000661
	(0.00284)	(0.00279)	(0.00279)
Partial Bathrooms	0.00130	0.00365	0.00473
	(0.00302)	(0.00299)	(0.00299)
Square Feet of Living Space	-5.83e-06	-1.00e-05	-4.89e-06
	(7.29e-06)	(6.93e-06)	(6.90e-06)
Square Feet^2	-1.45e-10	-3.86e-10	-8.28e-10
	(1.17e-09)	(1.12e-09)	(1.12e-09)
Lotsize (Acres)	0.000341	0.000646	0.000442
	(0.000463)	(0.000451)	(0.000441)
Lotsize^2	-1.89e-06	-3.24e-06	-2.59e-06
	(2.34e-06)	(2.45e-06)	(2.32e-06)
Lotsize Missing	-0.00674	-0.0139**	-0.0131**
	(0.00589)	(0.00587)	(0.00587)
Has $<$ in Lot Dimensions	0.0170***	0.0120***	0.0113***
	(0.00388)	(0.00380)	(0.00380)
Has $>$ in Lot Dimensions	0.00580	0.00888	0.00746
	(0.0202)	(0.0200)	(0.0200)
Age (Years)	0.000159	-0.000322**	-0.000400***
	(0.000153)	(0.000130)	(0.000130)
Age^2	4.53e-07	1.78e-06	1.89e-06
	(1.38e-06)	(1.21e-06)	(1.21e-06)
Age Unknown	-0.00419	-0.0103	-0.0105
	(0.0114)	(0.0112)	(0.0112)

Table A2.11 (continued)

VARIABLES	(1) Sold by Franchise	(2) Sold by Franchise	(3) Sold by Franchise
Fireplace	0.0103***	0.0111***	0.0135***
	(0.00305)	(0.00298)	(0.00296)
Basement	-0.00207	-0.00151	-0.00142
	(0.00310)	(0.00295)	(0.00295)
Finished Basement	0.00116	-0.000264	0.000559
	(0.00382)	(0.00379)	(0.00379)
Central Air	0.00472	0.0102**	0.0101**
	(0.00430)	(0.00425)	(0.00425)
Brick Exterior	0.00190	0.00208	0.00134
	(0.00287)	(0.00280)	(0.00280)
Vinyl Exterior	0.00900**	0.0150***	0.0148***
	(0.00366)	(0.00354)	(0.00354)
Metal Roof	0.00455	-0.000551	-0.00151
	(0.0124)	(0.0123)	(0.0123)
Composition Roof	0.0200***	0.0118**	0.0113**
	(0.00578)	(0.00574)	(0.00575)
Ranch Style	0.00339	0.00851***	0.00716**
	(0.00322)	(0.00312)	(0.00312)
Modular Style	0.0281***	0.0248**	0.0218**
	(0.0101)	(0.00973)	(0.00972)
Cape Cod Style	-0.00867*	-0.00888*	-0.0108**
	(0.00483)	(0.00471)	(0.00471)
Carport	-0.0138**	-0.0323***	-0.0340***
	(0.00590)	(0.00578)	(0.00578)
Garage	-0.0161***	-0.0521***	-0.0527***
	(0.00429)	(0.00361)	(0.00361)
One Car Garage	0.0152***	0.0477***	0.0486***
	(0.00504)	(0.00468)	(0.00468)
Multiple Car Garage	0.0185***	0.0541***	0.0545***
	(0.00470)	(0.00431)	(0.00431)
Within 1 Mile Parkway/Interstate	0.00405	-0.0121***	-0.00940***
	(0.00442)	(0.00264)	(0.00263)
Within 1 Mile Railroad	0.000138	-0.00575**	-0.00563**
	(0.00414)	(0.00258)	(0.00258)
Constant	-0.121	0.184***	0.193***
	(0.0968)	(0.0235)	(0.0236)
Observations	145,851	145,851	145,851
R-squared	0.128	0.116	0.116
Year-Month Dummies	Yes	Yes	Yes
Tract Fixed Effects	Yes	No	No

Table A3.12: Regression Results For Comparison of Listing Brokers and Out-of-State Movers. Central Kentucky Data, 2000-2011

VARIABLES	(1) Listed by Franchise	(2) Listed by Franchise	(3) Listed by Franchise
5 Miles Ft. Knox	0.0123		
	(0.0118)		
% Out of State 5 Years Ago		0.00296***	
		(0.000280)	
% Out of State 1 Year Ago			0.000277***
			(6.77e-05)
Constant	0.521***	0.442***	0.454***
	(0.160)	(0.0259)	(0.0260)
Observations	145,851	145,851	145,851
R-squared	0.046	0.012	0.011
Year-Month Dummies	Yes	Yes	Yes
Tract Fixed Effects	Yes	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road.

[b] Robust Standard Errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

[c] There were 18 observations where this variable was missing. These observations were set to zero, and a dummy variable equal to one was included indicating there was a missing value.
*** p<0.01, ** p<0.05, * p<0.1

Table A2.13: Average Number of Listing Agents Per Year & Number of Observations for Each Franchised Broker

Firm	Agents Per Year	Obs.	Firm	Agents Per Year	Obs.
C21_List_159	1.31	13	Remax_List_748	20.94	2124
C21_List_160	7.58	321	Remax_List_749	3.69	87
C21_List_161	9.30	142	Remax_List_750	10.15	1221
C21_List_162	20.99	927	Remax_List_751	50.17	5879
C21_List_163	14.03	677	Remax_List_752	10	49
C21_List_164	5.74	115	Remax_List_753	2.59	132
C21_List_165	4.62	468	Remax_List_754	1	7
C21_List_166	1.53	72	Remax_List_755	19.41	5977
C21_List_167	91.16	5904	Remax_List_756	3	13
C21_List_168	2	2	Remax_List_757	6.47	47
C21_List_169	9.80	922	Remax_List_758	1	3
C21_List_170	73.72	1308	Remax_List_759	1	3
C21_List_171	5.92	150	Remax_List_760	15.06	251
C21_List_172	7.33	187	Remax_List_761	2	2
Coldwell_List_192	10.53	470	Remax_List_762	4.47	47
Coldwell_List_193	25.21	1458	Remax_List_763	9.79	547
Coldwell_List_194	1	3	Remax_List_764	1.33	15
Coldwell_List_195	18.77	1252	Remax_List_765	12.43	743
Coldwell_List_1033	20.21	746	Remax_List_766	1	45
Coldwell_List_1034	22.23	1133	Remax_List_767	1.77	13
Coldwell_List_1035	99.37	6524	Remax_List_1038	25.81	1632
Coldwell_List_1036	10.3	560	Remax_List_1039	35.42	2629
Coldwell_List_1037	1	2	Remax_List_1040	14.82	1196
Keller_List_506	1	2	Remax_List_1041	18.42	724
Keller_List_507	2	4	Remax_List_1042	10.27	813
Keller_List_509	40.4	1071	Remax_List_1043	28.48	1805
Keller_List_1045	47.34	998	Remax_List_1044	96.46	10296

This table shows how many listing agents each individual franchise had per year and the total number of times each franchise appears in the sample. The numbers corresponding to an individual firm have no significance and are only used to anonymously identify the firms.

Table A2.14: Marginal Effects for Dummy Variables Regressions Evaluated at the Sample Means. Central Kentucky Data, 2000-2011

VARIABLES	(1) Sold Own Listing	(2) Sold Own Listing	(3) Sold by Franchise	(4) Sold by Franchise	(5) Sold by Franchise
Listed by RE/MAX		-0.0116			
Listed by Coldwell Banker		-0.0311			
Listed by Century 21		-0.0456			
Listed by Keller Williams		0.0109			
# of Selling Agents in Listing Firm	0.000179	0.000181			
Listed by Franchise	-0.0213		0.312	0.323	0.324
5 Miles Ft. Knox			0.0147		
% Out of State 5 Years Ago				0.00251	
% Out of State 1 Year Ago					0.000347
Observations	145,686	145,686	145,533	145,851	145,851
Year-Month Dummies	Yes	Yes	Yes	Yes	Yes
Tract Fixed Effects	Yes	Yes	Yes	No	No

[a] Also included in each regression are: bedrooms, full bathrooms, partial bathrooms, square feet, square feet^2, lot size, lot size missing, age, age^2, age unknown, fireplace, basement, finished basement, central air, exterior type, roof type, style of home, garage, carport, 1 mile parkway/interstate, 1 mile rail road, 5 miles Ft. Knox.

[b] The OLS results are presented in Table 3.5

[c] The OLS results are presented in Table 3.12

Table A2.15: Hypotheses, Specifications, and Results

Hypothesis	Equation	Expected Result	Empirical Result	Interpretation
$P_F = P_I$ (Theory Model Prediction)	$ln(\text{List Price})_{ijt} = \text{Franchised}_{ijt}\omega + x_{ijt}\psi + \sigma_t + \delta_j + \epsilon_{ijt}$	$\omega = 0$	$\omega < 0$	Reject the null hypothesis that franchised and independent listing brokers choose the same list price.
$\Phi_F < \Phi_I$ (Theory Model Prediction)	$\text{SoldOwn}_{ijt} = \text{Franchised}_{ijt}\rho + x_{ijt}\psi + \sigma_t + \delta_j + \epsilon_{ijt}$	$\rho < 0$	$\rho < 0$	Franchised listing brokers are about 2% less likely to sell their own listings compared to independent listing brokers.
Sales prices for franchised listings should be $\geq$ independent brokers listings.	$ln(SalesPrice)_{ijt} = \text{Firms}_{ijt}\omega + x_{ijt}\psi + \sigma_t + \delta_j + \epsilon_{ijt}$	$\omega \geq 0$	$\omega = 0$	Result depends on the specification
Days on market for franchised listings should be $\leq$ independent brokers listings.	$DOM_{ijt} = \text{Firms}_{ijt}\omega + x_{ijt}\psi + DOP\zeta + \sigma_t + \delta_j + \epsilon_{ijt}$	$\omega \leq 0$	$\omega < 0$	On average, houses listed with franchised brokers sell sooner.
Franchised Firms are more active in areas with more out-of-state movers	$\text{SBF}_{ijt} = \text{OutOfState}_{ijt}\gamma + \text{Firm}_{ijt}\Delta + x_{ijt}\beta + \sigma_t + \delta_j + \epsilon_{ijt}$	$\gamma > 0$	$\gamma > 0$	Franchised brokers are more likely to sell houses in areas where a higher percentage of the residents are moving from out of state.

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