IMPROVED INFORMATION SHOCK AND PRICE DISPERSION: A NATURAL EXPERIMENT IN THE HOUSING MARKET

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Abstract

This research employs data from a natural experiment to assess the effect of improved price information shock on subsequent real estate transaction price dispersion. While transaction data in the Israeli real estate market had never been open to the public, in 2010 an Israeli court ordered the Israel Tax Authority to post all real estate transaction data on its website. We employ all housing transactions in the period prior and subsequent to this event to assess its effect on housing price dispersion. Results provide strong evidence of improved market efficiency as indicated by a significant decrease in the dispersion of quality-adjusted prices. We further find evidence that the information shock effect on price dispersion varies with household characteristics in the market. Our findings support the market transparency argument for promoting economic efficiency and equity.

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1. INTRODUCTION

Economists have long recognized the central role of information in the operation of markets. For example, when information is costly or imperfect, sub-optimal welfare is likely to be attained, and market equilibrium may exhibit price dispersion even for homogeneous goods [see, e.g., Stiglitz (1985) and Stigler (1961), respectively].[1] Interestingly, while a great deal of theoretical and empirical research has been devoted to understanding the effect of information on prices, to date only limited empirical work has been done on the specific effect of information shocks on price dispersion of goods.

An exception to this trend is a study by Jensen (2007) on the effect of improved information technology shock on price dispersion and welfare in the fishing industry in Kerala, India. According to Jensen (2007), information shock that was associated with the introduction of mobile phone service to fishermen and wholesalers has led to a reduction in price dispersion in the South Indian fisheries sector [similarly, Aker (2010) finds that the introduction of mobile phone services reduced price dispersion across grain markets in Niger].[2]

A recent experience in the Israeli real estate market serves as a natural experiment for further exploring the effect of information availability on price dispersion in a market where transactions carry considerable individual economic consequences. Specifically, in 2010 an Israeli court ordered the Israel Tax Authority to open its records to the public on all past and current real estate transactions. For the first time, price and other related real estate transaction

[1] Studies on the role of information in markets are too numerous to cite. See Stiglitz (1985) for a thorough review of the role of information in economic analysis.

[2] Note that unlike Fama *et al.* (1969) and many others that followed, we do not focus on the price reaction to new (favorable or unfavorable) information per se; rather, along the lines of Jensen (2007), we focus on the effect of improved information on price dispersion. Prevailing rational explanations for the price dispersion of a given good include the cost of information collection [e.g., Stigler (1961), Rothschild (1973), and, more recently, Janssen and Moraga-González (2004) and Janssen, Moraga-González, and Wildenbeest (2005)] and consumer heterogeneity in a "clearinghouse" setting [e.g., Salop and Stiglitz (1977), Varian (1980), and, more recently, Baye and Morgan (2001) and Baye, Morgan, and Scholten (2004)]. Empirical studies of price dispersion in particular account for explanations such as the absolute value of the good [e.g., Pratt *et al*. (1979) and, more recently, Gatti and Kattuman (2003) and Eckard (2004)]; purchase frequency [e.g., Sorensen (2000)]; number of competing sellers in the market [Borenstein and Rose (1994) and Barron *et al*. (2004)]; and search cost [e.g., Brown and Goolsbee (2002), Brynjolfsson and Smith (2000), Smith and Brynjolfsson (2001), and Dinlersoz and Li (2006)]. Several studies also examine the persistence of price dispersion over time [see, among others, Lach (2002)]. Finally, see the comprehensive review of price dispersion literature in Baye *et al*. (2006).

information was disclosed to market participants and was freely accessed through the Tax Authority's website.[3]

We study the effect of the public disclosure of housing transaction data on the price dispersion of subsequent transaction prices. In particular, by observing all market transaction prices prior and subsequent to the improved information shock, we estimate the change in the dispersion of quality-adjusted housing prices over time and across locations. Moreover, we examine the sensitivity of the estimated price dispersion effect to such characteristics as household education, income, and socio-economic status in the market. Finally, we examine the robustness of our findings to issues of sampling and test specifications.[4]

The results provide solid evidence of decreased price dispersion that follows the public disclosure of transaction price information. Specifically, the standard deviation of quality-adjusted prices has decreased by about 17% subsequent to the improved information shock. Further, we find that the effect of the improved information shock on price dispersion is negatively correlated with market participant education, income, and socio-economic status. The results are robust to sampling and test design issues.

The key contribution of this research is threefold. First, our natural experiment setting provides us with a precise and clean examination of the effect of information shock on price dispersion. [As noted above, to the best of our knowledge, Jensen (2007) and Aker (2010) are the only previous studies that provide such evidence, although their framework and type of information shock are different than those examined here.] Further, we extend Jensen's (2007) and Aker's (2010) evidence to a market of non-homogeneous goods where each transaction involves significant and long-term individual economic consequences. Finally, we show that the improved information shock carries a significant equity effect. In particular, we find that decreased price dispersion inversely correlates with level of income, education, and socio-economic status.

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[3] Our study thus further relates to the ambiguous evidence on the effect of online markets on price dispersion of goods [see, among others, Bailey (1998), Brynjolfsson and Smith (2000), Clemons *et al*. (2002), and Baye *et al*. (2006)].

[4] Eerola and Lyytikäinen (2015) use a conceptually similar natural experiment setting in the Finnish housing market to explore the effect of an improved information shock on the price level and time-on-the-market of transacted assets. Also, two other studies find that price dispersion in the housing market correlates with market activity [Yiu *et al.* (2009)] and, to a limited extent, with macro-economic variables [Leung *et al.* (2006)].

The remainder of the paper proceeds as follows: Section 2 provides further institutional background and Section 3 describes the data. Section 4 describes the methodology and Section 5 presents the results. Section 6 presents a series of robustness tests, while Section 7 presents the sensitivity of the results to market participant characteristics. Finally, Section 8 provides a summary and concluding remarks.

2. BACKGROUND

Israeli law requires that the parties involved in a real estate transaction provide a report to the Israel Tax Authority upon the closing of the transaction. This report must include the closing price as well as information on fundamental attributes of the transacted asset. While the Tax Authority traditionally collected the data on every single transaction, the information was never available to the public (nor to market professionals). Moreover, unlike the multiple listing method in the United States, the common practice in Israel is that each broker privately manages its listing of assets for sale, which is not shared with other brokers.[5] Thus, in order to assess market prices, land appraisers, real estate brokers, and other professionals had to rely on limited information sources (such as past transactions in which they were personally involved and asked prices that appeared in their listing). Obviously, under such circumstances, the general public (including buyers and sellers) had no formal access to transaction price information—and, in fact, had very limited access to non-formal information sources.

Only in mid-April 2010, following a court order, did the Israel Tax Authority begin to publish micro-level information on all real estate transactions in Israel.[6] For the first time, access

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[5] Housing units for sale in Israel are offered mainly through real estate brokers or person-to-person. (Auctions are very rare.) According to our data on asking prices (see further description in Section 6 below), the share of broker transactions in the market is about 58%. Generally, there are a number of brokers dominating each sub-market (neighborhood); however, information is rarely shared among brokers. Also, it should be noted that about 93% of the residential market consists of condominium apartments, where ownership rate is about 68%, and about 93% of the households are located in urban areas (see Central Bureau of Statistics, 2015).

[6] The petition that was submitted to the court by two members of academia (for proper disclosure, one of whom is an author of this article) requested that the Israel Tax Authority disclose all real estate transaction data in Israel. The petition was originally submitted to the court in March 2009. Two court meetings followed between September and December 2009. Finally, in February 2010, the judge ordered the publication of the data within a reasonable timeframe. Until this judge's order, the petition received insignificant media coverage and public attention. The judge's decision, however, which was greeted with great surprise by the involved parties, led (as noted above) to the first publication of the data in April 2010—an event that received extensive media coverage (see Israel Tax Authority media announcement in https://taxes.gov.il/About/SpokesmanAnnouncements/Pages/ConvertAnnPage_613.aspx [April 13, 2010]).

to the nationwide transaction information was provided at no charge through the Tax Authority's website, and the data were continuously updated with new transaction closings coming in (the original information release included transactions from 1998 onward). In fact, the publication of the data was completed in two phases. In April 2010 the Tax Authority's data website was launched; however, the interface was "unfriendly" and only provided data on the asset price and its location (excluding its physical attributes). In the second phase, however, some six months later (in October 2010) the website was upgraded, allowing for simpler access by non-professional users and, moreover, provided more complete information on each transacted asset, including number of rooms, area in square meters, age of the structure, floor number, and the number of floors in the structure where the asset is located.[7]

Figures 1A–1C show statistics of Google Trends' "Search Interest" resulting from a search for the terms "apartment prices tax authority," "real estate information," and "apartment prices" (translated from Hebrew), respectively, over the period January 2007 to December 2014. Several patterns are evident. First, one can see the relatively insignificant search volume until March 2010. Thereafter, subsequent to the launch of the Tax Authority's transaction information website in April, a first search peak is recorded in May 2010. Another peak follows in October–November 2010, concurrent with the upgrade of the Tax Authority website. Finally, in the period subsequent to November 2010, search volume maintains a level greater than that recorded during the pre-information disclosure period, as availability of the data on the web turned the search for transaction closings into a routine practice for real estate market participants.[8]

3. SAMPLE DESCRIPTION

Additional public attention accompanied the upgrade of the website in October 2010 when additional attributes of the transacted assets became public [see Israel Tax Authority media announcement in https://taxes.gov.il/About/SpokesmanAnnouncements/Pages/ConvertAnnPage_810.aspx (October 17, 2010)]. Importantly, given this order of events, the disclosure of the data may be considered as an *exogenous* shock to the real estate market.

[7] It should be further noted that in March 2011, another (private) website was launched providing access to the Tax Authority transaction data at no charge and in a highly accessible and user-friendly manner. Several other private websites followed over the years.

[8] As mentioned above, a number of private websites where launched in the year following the data disclosure by the Tax Authority. This may explain not only the overall search volume post-October 2010, but also the relatively higher volume for the terms "real estate information" and "apartment prices," as compared to "apartment price *tax authority*" in the post-2012 period.

We use the above-described institutional development in the Israeli real estate market to study the effect of the price information shock on housing unit price dispersion. Our sample includes the universe of all housing transactions in Israel over the period 2007–2013, a total of 249,173 observations.[9] Specifically, as further described in the next section, we estimate and compare the dispersion of quality-adjusted prices over the three years prior to the price information disclosure of April 2010, when the Tax Authority's website was originally launched with partial information on housing transactions (i.e., from April 2007 to March 2010) and the three years subsequent to the complete information provision—that is, when the website was upgraded in October 2010 (i.e., from November 2010 to October 2013).[10]

The sample comprises the information that is provided on the Israel Tax Authority website on each housing unit transaction, including the closing price and date as well as a series of asset attributes. Table 1 presents summary statistics of the sample of transactions. As indicated in the table, the typical dwelling unit is a 3.7-room, 954-square-foot condominium apartment located on the second floor of a 25-year-old structure. The average unit price is about $279,000, with a standard deviation of about $197,000.[11]

Table 2 further presents summary statistics for the sample of city panel across all time periods. As shown, the average value of *Treatment*, an indicator variable that equals 1 for post-information shock periods and zero otherwise, is about 0.5. The table also provides information on a set of control variables including $\Delta SD\_\hat{P}_{tc}$, the first difference of the 6-month (ending at t) moving standard deviation of quality-adjusted (log of) housing prices in city c (more on the

[9] In order to reliably assess the price dispersion, we omitted observations in cases where fewer than 30 transactions occurred in a given city in a given period (month) and, moreover, we required that each city appear at least in one period both prior and subsequent to the information shock (see further description in Section 4 below). Hence, from the raw sample of 312,341 observations over the period 2007–2013, we are left with a final sample of 249,173 observations in 45 cities (out of the 76 cities in Israel), of which 12 appear in all 72 examined periods and 32 in at least 50 periods. Our estimation outcomes, however, are robust to changing the condition for city/month participation in the estimation from 30 transactions to either 20, 40, or 50 transactions (these results are not reported but are available on request).

[10] In that regard, our framework may be considered as a pre-post natural experiment.

[11] For convenience, prices are presented in US dollars, where 1 US dollar equals about 3.8 New Israeli shekels (NIS). Also, note that condominium apartments are the vast majority of housing assets in Israel. It follows from our data that about 95% of the universe of housing transactions over the 2007–2013 period includes condominium apartments.

derivation of $\Delta SD\_\hat{P}_{tc}$ can be found in Appendix A).[12] The average value of $\Delta SD\_\hat{P}_{tc}$ is about 0.01%. Other controls include the 6-month (ending at *t*) rate of change in quality-adjusted housing prices in city *c* (denoted by $\Delta\hat{P}_{tc}$), the average of which is 0.048;[13] the number of transactions per month *t* in city *c* (N_{tc}), the average of which is 101; and the first difference in the 3-month moving standard deviation of daily yields on the Tel Aviv 100 stock index (the Israeli equivalent of the S&P 500) (ΔSD_Stock_t), the average of which is about 0.01%. Finally, as shown in Table 2, the panel analysis controls for the average of dwelling unit characteristics in city *c* at time *t* (including Avg_Area_{tc}, Avg_Rooms_{tc}, Avg_Floor_{tc}, Avg_Age_{tc}, and $Avg\_SocioEcon_{tc}$) and the variance of dwelling unit characteristics in city *c* at time *t* (including SD_Area_{tc}, SD_Rooms_{tc}, SD_Floor_{tc}, SD_Age_{tc}, and $SD\_SocioEcon_{tc}$).

4. METHODOLOGY

Consider the following estimated model:

(1)

$$SD_{tc} = \alpha_0 + \alpha_1\, Treatment_t + \alpha_2 N_{tc} + \alpha_3 \Delta\hat{P}_{tc} + \alpha_4 \Delta SD\_\hat{P}_{tc} + \alpha_5 \Delta SD\_Stock_t + \vec{\alpha}_6 Avg\_Attributes_{tc} + \vec{\alpha}_7 SD\_Attributes_{tc} + \vec{\alpha}_8 Dum\_City_c + \varepsilon_{1tc}$$

and

(2)

$$\ln(P_{itc}) = \beta_{0,tc} + \beta_{1,tc}\ln(Rooms_{itc}) + \beta_{2,tc}\ln(Area_{itc}) + \beta_{3,tc}\ln(Age_{itc}) + \beta_{4,tc}\ln(Floor_{itc}) + \beta_{5,tc} Dum\_New_{itc} + \beta_{6,tc} SocioEcon_{itc} + \vec{\beta}_{7,tc} TYPE_{itc} + \varepsilon_{2itc}$$ for all *t* and c,

[12] We use $\Delta SD\_\hat{P}_{tc}$ as a control rather than $SD\_\hat{P}_{tc}$, as we reject the hypothesis of no unit-root in $SD\_\hat{P}_{tc}$. For the same reason we also use ΔSD_Stock_t as a control rather than SD_Stock_t in the analysis that follows.

[13] Note the relatively high average return on the quality-adjusted prices over the examined period. Following Pratt *et al*. (1979), Gatti and Kattuman (2003), Eckard (2004), and others who present evidence of an inverse correlation between the value of a good and its price dispersion, we control for the changes in quality-adjusted housing price. However, as the unit-root hypothesis for the quality-adjusted price *level* is not rejected (Fisher-type test based on ADF *p*-value equal to 0.967), we specify this non-stationary control variable in difference terms (the latter is found to be stationary; unit-root hypothesis is rejected at the 1% level). As shown below, our results on the correlation between price returns and price dispersion are consistent with previous literature.

where equation (1) examines the effect of the price information shock on price dispersion and equation (2) is an auxiliary equation whose objective is to estimate the price dispersion to be substituted into equation (1), as further described below.

The dependent variable in equation (1), SD_{tc}, is the standard deviation of ε_{2itc} that follows from equation (2) [see further description of (2) below], where subscripts *i*, *t*, and *c* denote transactions, months, and cities, respectively. The independent variables in equation (1) include $Treatment_t$, indicating post-information shock periods (a dummy variable that equals 1 for post-October 2010 periods and zero for pre-April 2010 periods) and a series of control variables comprised of N_{tc}, the number of transactions at time *t* in city *c*, reflecting the amount of information that is generated by market depth;[14] $\Delta\hat{P}_{tc}$, the 6-month (ending at *t*) rate of change in quality-adjusted housing prices in city *c*, controlling for the changes in the price level that may associate with price dispersion; $\Delta SD\_\hat{P}_{tc}$, the first difference in the 6-month (ending at *t*) moving standard deviation of quality-adjusted housing prices in city *c*, controlling for the volatility in the time-series of the price that may affect the time *t* cross-sectional (across transacted units) quality-adjusted price dispersion (for the derivation of $SD\_\hat{P}_{tc}$ and $\Delta\hat{P}_{tc}$, see Appendix A); ΔSD_Stock_t, the first difference in the 3-month moving average of the standard deviation of daily yields on the Tel Aviv 100 stock index, proxying the current level of uncertainty in the economy; $Avg\_Attributes_{tc}$ and $SD\_Attributes_{tc}$, respective vectors of the average and standard deviation of dwelling attributes (across transacted dwellings at each couplet *t* and *c*), controlling for potential correlation between SD_{tc} and the distribution of dwelling unit attributes across time and space; and Dum_City_c, a city fixed-effect indicator. Finally, the parameters $\alpha_0 - \alpha_5$ are estimated coefficients, $\vec{\alpha}_6 - \vec{\alpha}_8$ are vectors of estimated coefficients, and ε_{1itc} is a random disturbance term.

In addition, equation (2) is a hedonic price equation estimated for each couplet *c* and *t* (i.e., for each city at every period). We use the estimation of equation (2) to generate the standard

[14] To address the possible endogeneity between SD_{ct} and N_{ct} in the estimation of equation (1), we also employed a 2SLS procedure, where in the first stage we estimate N_{ct} as a dependent variable on a set of exogenous variables (including rate of change in average quality-adjusted housing prices in city *c*, rate of change in city population, the number of construction starts and completions; rate of change in gross domestic product; and a city fixed-effect), and in the second stage we substitute the fitted value from the first-stage estimation, $\hat{N}_{ct}$, into the right-hand side of equation (1). It follows from the estimation of equation (1), however, that the coefficient on both N_{ct} and $\hat{N}_{ct}$ is insignificantly correlated with SD_{ct} (results from the 2SLS procedure are not presented but are available upon request; thus, to simplify the presentation, the 2SLS procedure is omitted.

deviation of the residuals ε_{2itc} for every t and c, SD_{tc}, to be substituted on the left-hand side of equation (1). The dependent variable in equation (2), ln (P_{itc}), is the log of the closing price of transaction i at time t in city c, and the independent variables in (2) include a series of asset characteristics: *Rooms*, the number of rooms; *Area*, the floor area (in square feet); *Age*, the structure's age (in years); *Floor*, the floor of the structure on which the asset is located; *Dum_New*, an indicator variable for new units (equals one if *Age* is less than one year; zero otherwise); *SocioEcon*, the score on a socio-economic index of the statistical area where property i is located;[15] and *TYPE*, a vector indicating the dwelling type (condominium apartment, garden apartment, duplex, penthouse, townhouse, attached, or single-family unit). Also, $\beta_0 - \beta_6$ are estimated parameters, $\vec{\beta}_7$ is an estimated vector of parameters, and ε_{2itc} is a disturbance term.[16]

The derivation of SD_{tc} in equation (2) and its substitution in the panel specification of equation (1) are designed to test the effect of improved information shock on price dispersion. We anticipate that the sudden availability of price information is followed by a decreased standard deviation of the residuals [from equation (2)], that is, that $\alpha_1 < 0$ in estimated equation (1).

In sum, based on the universe of all housing transactions in city c at period t, we estimate a series of hedonic price models in equation (2) for each couplet c and t [total of 45 cities over up to 72 monthly periods—altogether 2,475 estimations of equation (2)]. Following this first-step estimation we compute SD_{tc} and then employ an unbalanced monthly panel data of all cities over the period 2007–2013 (2,475 observations in total) to estimate equation (1) to test the effect of the price information shock on subsequent price dispersion.

[15] A statistical area—the Israeli equivalent of a census tract—is the smallest geographic area examined by the Israel Central Bureau of Statistics (see more on this geographical unit in Section 6 below). The socio-economic index (provided by the Israel Central Bureau of Statistics) may range from -3 to +3 and is generated by 16 indicators of the statistical area, clustered into 4 groups: standard of living, employment and welfare, schooling and education, and demography (see Israel Central Bureau of Statistics, 2013).

[16] Note that the log transformation in equation (2) reduces potential heteroskedasticity [see, among many others, Clemons *et al*. (2002)]. We performed a Breusch-Pagan test for heteroskedasticity for all estimations of equation (2) (i.e., for all c and t). In more than 60% (80%) of the cases, the homoskedasticity hypothesis could not be rejected at the 10% (1%) significance level. The outcomes from the estimation of equation (1) are robust to the omission of SD_{tc} observations for which the homoskedasticity hypothesis in equation (2) is rejected (outcomes from the robustness test are not reported but are available upon request). Importantly, however, note that the validity of our test in equation (1) maintains even if heteroskedasticity exist in (2), as our focus in this auxiliary equation is to derive the standard deviation of ε_{2itc} rather than estimate the coefficients per se.

5. RESULTS

Table 3 presents the results of panel estimation that tests for the effect of the price information disclosure shock on the dispersion of subsequent quality-adjusted transaction closing prices. Column 1 presents the outcomes obtained from the estimation of equation (1) over the period April 2007–March 2010 (36 months of pre-information shock) and November 2010–October 2013 (36 months of post-information shock).[17] Empirical findings provide solid evidence in support of an information effect on the dispersion of quality-adjusted prices. The coefficient on the *Treatment* variable is negative and significant at the 1% level. In particular, improved information shock associates with a decreased *SD* of 3.1% of property value. As the average standard deviation of the residuals in the period prior to the price disclosure equals 0.184, this implies roughly a 17% decrease in price dispersion due to improved information shock.[18]

Column 2 in Table 3 present the outcomes from re-estimating equation (1) over the periods April 2009–March 2010 and November 2010–October 2011 (that is, 12 months prior and subsequent to the information shock). It follows that while price dispersion significantly drops with improved information shock, the short-term (12-month subsequent) effect is smaller in magnitude. The coefficient on the *Treatment* variable implies about a 8% decrease in price dispersion (i.e., relative to the average standard deviation of the residuals in the pre-information shock period).

Further, we repeat the estimation of equation (1) for the 2007–2013 and 2009–2011 periods, substituting the *SD* measure of dispersion on the left-hand side of (1) with *P*75-*P*25, the difference between the residuals in the 75th and the 25th percentiles (of the residual distribution) that follow from the estimation of equation (2) (summary statistics of *P*75-*P*25 are presented in

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[17] We use robust standard errors in the estimation of equation (1) as the homoskedasticity assumption is rejected (Chi2 (42) = 1155; *p*-value < 0.0001). Note that we cannot reject the no-serial correlation assumption in (1) (Wooldridge test generates F-statistic (1,42) = 1.023; *p*-value = 0.317). Also, outcomes are robust to using weighted least-squares in the estimation of (1), where weights are determined by the total number of transactions in each city. The average R^2 coefficient from the estimations of equation (2) is equal to 0.81 [outcomes from the estimations of auxiliary equation (2) are not reported but are available upon request]. Finally, summary statistics of SD_{tc}, the standard error of the residuals from the estimated price equation (2), are presented in Table 2. As can be seen, the average and standard deviation of SD_{tc} are 0.18 and 0.05, respectively.

[18] Note that the standard deviation of the residuals from equation (2), *SD*, is estimated in log of asset price. Hence, the residuals represent errors in percentage of asset value.

Table 2). This price dispersion measure is robust to outliers in the price observations. Results of this specification are presented in columns 3 and 4 of Table 3. It follows that estimation outcomes are robust to this specification. The improved information shock associates with about a 3.9% (1.7%) decrease (both significant at the 1% level) in $P75$-$P25$ for the 36- (12-) month pre- and post-treatment time frame. As the average value of $P75$-$P25$ prior to the information shock is equal to 0.22, our outcome indicates about a 17% (8%) decrease in the price dispersion over the 36- (12-) month period subsequent to the information shock under this alternative measure.

Results are further robust to: (*a*) changing the left-hand side variable in equation (1), $P75$-$P25$, with either $P90$-$P10$ or *Pmax-Pmin*, that is, the difference between the residuals in the 90th and the 10th percentiles or the difference between the maximum and minimum, respectively, of the residual distribution that follows from the estimation of equation (2); (*b*) the substitution of the left-hand side variable in (1) with its natural logarithm; (*c*) the omission of the city fixed-effect variable (*Dum_City*) and the omission of the average attributes ($Avg\_Attributes$) and their standard deviation (*SD_Attributes*) in (1); (*d*) including only the 10, 20, and 30 most active (transaction-wise) cities in the sample; (*e*) excluding the 10, 20, and 30 most active cities from the sample; and (*f*) changing the condition for city/month participation in the estimation from a minimum of 30 transactions to either 20, 40, or 50 transactions (results from these robustness tests are not reported but are available upon request).

Finally, the estimated coefficients of the control variables are as follows: Consistent with previous literature [see, e.g., Gatti and Kattuman (2003); Eckard (2004)], price dispersion negatively correlates with price change, as a 1% increase in the quality-adjusted price associates with a decrease in *SD* equal to 0.024% of property value (significant at the 5% level and equivalent to about a 0.1% decrease in price dispersion). In addition, an increase in the 6-month (ending at *t*) time-series standard deviation of quality-adjusted housing prices associates with an increased *SD* (significant at the 5% level), while an increase in the standard deviation of stock prices and the number of transactions insignificantly correlates with *SD*.

6. ADDITIONAL ROBUSTNESS TESTS

In this section, we assess the robustness of our findings to issues of sampling and test design.

Smaller Geographical Areas

The estimation of equation (1) reported above shows that improved information shock associates with a considerable decrease in the dispersion of subsequent transaction prices. This outcome is based on a panel of monthly observations in the 45 most active cities. We now augment those findings on the correlation between the price information shock and subsequent price dispersion by focusing on smaller geographical areas. The Israel Central Bureau of Statistics divides all municipalities in Israel hosting no fewer than 10,000 residents into geographical units referred to as statistical areas (the smallest sampling unit employed by the Central Bureau of Statistics), which are equivalent to census tracts in the United States. Each statistical area includes about 3,000–5,000 residents, and, as with census tracts, the division into statistical areas accounts for aspects of homogeneity with respect to population characteristics, economic status, and living conditions (see Israel Central Bureau of Statistics, 2013).[19]

The analytic gain from using these smaller geographical units comes, however, with a decreased number of transactions per location per period. We thus extend the time-unit of the statistical area panel to one year. Altogether, our panel thus includes all housing transactions in 608 statistical areas (a total of 171,810 observations) over the periods April 2007–March 2010 and November 2010–October 2013 (i.e., three complete years prior and subsequent to the price information shock).[20] Table 4 presents summary statistics of this sample. As indicated in the table, the average dwelling unit across statistical areas is a 3.6-room, 918-square-foot condominium apartment located on the 2nd floor of a 26-year-old structure.

In the spirit of equations (1) and (2) above, consider the following estimated equations:

(1a)

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[19] For example, the three largest cities in Israel—Jerusalem, Tel Aviv, and Haifa—include 181, 164, and 91 statistical areas, respectively.

[20] Similar to the organization of the sample under the city-level estimation, we condition the inclusion of a statistical area *s* at year *t* in the sample on exhibiting no fewer than 30 transactions per couplet *s* and *t*. We further omit statistical areas that do not satisfy the minimum-30-transaction condition for some *t* both prior and subsequent to the information shock. Our estimation outcomes, however, are robust to changing the condition for statistical area/year participation in the estimation from a minimum of 30 transactions to either 20, 40, or 50 transactions (these results are not reported but are available on request).

$$SD_{\tau s} = \delta_0 + \delta_1 Treatment_\tau + \delta_2 N_{s\tau-1} + \delta_3 \Delta\hat{P}_{\tau s} + \delta_4 |\hat{\theta}_{6,\tau s}| + \delta_5 SD\_Stock_\tau + \vec{\delta}_6 Avg\_Attributes_{\tau s} + \vec{\delta}_7 Var\_Attributes_{\tau s} + \vec{\delta}_8 Dum\_StatArea_s + \varepsilon_{3\tau s}$$

and

(2a)

$$\ln(P_{i\tau s}) = \theta_{0,\tau s} + \theta_{1,\tau s}\ln(Room_{i\tau s}) + \theta_{2,ts}\ln(Area_{i\tau s}) + \theta_{3,ts}\ln(Age_{i\tau s}) + \theta_{4,\tau s}\ln(Floor_{i\tau s}) + \theta_{5,ts}Dum\_New_{i\tau s} + \theta_{6,ts}Month_{i\tau s} + \vec{\theta}_{7,ts}TYPE_{i\tau s} + \varepsilon_{4i\tau s}$$ for all τ and *s*,

where subscripts *i*, τ, and *s* stand for transactions, annual time periods, and statistical areas, respectively, and where equation (1a) examines the effect of the price information shock on price dispersion and equation (2a) is an auxiliary equation whose objective is to estimate the quality-adjusted price dispersion—with both equation estimations being based on a statistical area-level sample.

Equations (1a) and (2a) are, respectively, similar to (1) and (2) with the following adjustments. The independent variables in equation (1a) include $\Delta\hat{P}_{\tau s}$, the change in the quality-adjusted price in *s* over the period (year) τ, controlling for the change in the price level that may associate with price dispersion; $|\hat{\theta}_{6,ts}|$, the absolute value of the estimated coefficient on the variable *Month* from equation (2a), controlling for within-period (year) time-series price changes that may affect the level of price dispersion (see further description of *Month* below);[21] and $Dum\_StatArea_s$, a statistical area fixed-effect indictor. Also, $\delta_0 - \delta_5$ are estimated parameters, $\vec{\delta}_6 - \vec{\delta}_8$ are vectors of estimated parameters, $\varepsilon_{3s\tau}$ is a random disturbance term, and all other variables are as discussed above (corresponding to statistical areas and annual time periods).

Equation (2a) is a statistical area-based hedonic price equation estimated for each couplet *s* and τ from which we generate the standard deviation of the residuals ε_{4itc}, $SD_{\tau s}$, substituted on the left-hand side of equation (1a). Equation (2a) differs from equation (2) above in two ways. First, the variable *SocioEcon* is omitted from (2a), as it is only available by statistical areas and thus does not vary for a given statistical area. Also, as we now consider annual time units, the

[21] As we use three pre- and post-treatment annual time periods in our statistical area-level estimation, we cannot compute the within-year standard deviation of the price. We thus proxy the latter using $\Delta\hat{P}_{\tau s}$ and $|\hat{\theta}_{6,ts}|$. Results are robust to using $\Delta\hat{P}_{\tau s}$ in absolute terms.

variable *Month* controls for monthly changes in the price level within the year.[22] In addition, $\theta_0 - \theta_6$ are estimated parameters, $\vec{\theta}_7$ is a vector of estimated parameters, $\varepsilon_{4s\tau}$ is a random disturbance term, and all other variables are as discussed above.

Column 1 in Table 5 presents the outcomes from the estimation of equation (1a) based on the statistical area sample.[23] Evidence is robust to this specification. Specifically, it follows from column 1 that the coefficient on the *Treatment* variable is equal to -0.024 (significant at the 1% level). Given that the average (across statistical areas) standard deviation of the residuals in the period prior to the price disclosure is 0.14, it follows that adjusted-price dispersion decreases by about 17%, *ceteris paribus*, subsequent to the price information shock. Column 2 in Table 5 further shows that the decreased price dispersion effect maintains when the examined time period is limited to one year prior and subsequent to the information shock (though the effect somewhat moderates to about 11%). Finally, columns 3 and 4 in Table 5 show that the outcome on the information shock effect is insensitive to substituting the price dispersion measure *SD* with *P*75-*P*25, the difference between the residual in the 75th and the 25th percentiles that follow from the estimation of Equation (2a).[24]

Placebo Effect

In order to further gauge our evidence on the effect of information shock on price dispersion, we re-estimate equation (1) with a placebo treatment over periods ending prior to the information shock. Recall that our investigation spans a period of 79 months—36 months prior and subsequent to the 7-month period (April–October 2010) of the information shock. We thus replicate this time-line over a pre-information shock period from January 2000 to April 2010. In particular, we specify time windows of 79 months—each of which includes 36 months of pre-

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[22] The variable *Month* assigns a number *m*=1,…,12 corresponding to the month when the transaction occurred in the observed year (e.g., *Month* equals 1 for transactions occurring in March prior to the information shock and to transactions occurring in November subsequent to the information shock). We use *Month* rather than 12 monthly dummy variables in order to avoid a decrease in the degrees of freedom.

[23] Estimation results from the estimation of equation (2a) (not reported) are available upon request.

[24] Summary statistics of the variables used in the statistical area level panel estimation are presented in Table 3. Among others, the average and standard deviation of $SD_{\tau s}$ is 0.14 and 0.05, respectively, and of $P75 - P25_{\tau s}$ is about 0.17 and 0.06, respectively. Also, the average R^2 of the 2,991 annual statistical area-level estimations of equation (2a) is 0.75.

placebo treatment, 7 months of placebo treatment, and 36 months of post-placebo treatment—based upon which we re-estimate equation (1) by the same method presented in Section 4 above. Altogether, we thus estimate equation (1) with a placebo treatment 45 times—once for every moving time window of 79 months—during the period January 2000–March 2010, where the variable *Treatment* is equal to 1 for post-placebo treatment periods, and 0 otherwise.

Figure 2 presents the estimated coefficient on the *Treatment* variable in the 45 placebo treatment estimations over the period January 2000–March 2010 (note that the first placebo treatment started in January 2003 following the 36 months of pre-treatment period). Confidence interval of the estimated coefficient is represented by the scattered lines. It follows that the coefficient on *Treatment* in all of the placebo treatment estimations is either insignificantly different from zero (in 24 out of the 45 placebo cases) or significantly positive (in 21 of the 45 cases). This outcome stands in stark contrast to the significantly negative sign obtained for the coefficient of the real treatment (discussed above).[25]

Information Inferred from Closing Versus Asking Prices

As noted earlier, about 58% of the transactions in Israel over the examined period were conducted by brokers (the remainder were mainly person-to-person), where, unlike the multiple listing method used by brokers in the US, brokers in Israel commonly manage their own personal listing (not shared with other brokers) of assets for sale. Given this institutional setting, however, it may be argued that the publication of all real estate transaction information in 2010 should have entailed no price dispersion effect, as market players could have inferred the same information prior to the closing price exposure by simply observing asking prices of relevant broker listings. In this section we thus test whether the public disclosure of closing prices conveyed any additional information beyond asking prices.

We obtained asking price data from a large (in fact the most popular) Israeli website, providing a platform for homeowners and brokers to offer housing units for sale on the internet. While the website was originally launched in 2005, a sufficient number of observations for the

[25] We similarly estimate the model in equation (1a) with placebo treatments based on statistical area data. Outcomes are robust to this variation, as the coefficient on all placebo treatments is either insignificantly different than zero or significantly positive (results are available upon request).

purpose of our test exists only as of January 2010.[26] Consistent with the analysis above, we stratify the sample of asking prices by pre-price information shock (January–March 2010) and post-price information shock (November 2010–October 2013). The raw sample includes a total of 463,958 observations. After omitting observations that do not maintain the minimum 30-asking-price per city *c* at month *t* condition, we are left with 382,242 observations [7,189 for the three-month-pre-information shock period (January–March 2010) and 375,053 for the three-year-post information shock period (November 2010–October 2013)]. Table 7 presents summary statistics of the sample of asking prices. As indicated in the table, the typical dwelling unit is a 3.6-room, 1022-square-foot apartment located on the third floor of a condominium structure. The average unit price is about $346,000, with a standard deviation of about $196,000.[27]

To assess the marginal effect of the public disclosure of closing (over asking prices) on closing price dispersion, for each *asking* price observation, P_{itc}^{Ask}, we compute a projected *closing* price, $\hat{P}_{itc}^{Close}$ based on asset *i*'s characteristics (asset *i* for which P_{itc}^{Ask} is observed) and the estimation of equation (2) (using the closing price data—again, see section 4 above). We then compute $P_{itc}^{Ask} - \hat{P}_{itc}^{Close}$, the difference between each asking price and its corresponding projected closing price, across all asking price observations. Finally, we calculate the standard deviation of $P_{itc}^{Ask} - \hat{P}_{itc}^{Close}$ for all couplets *t* and *c* (i.e., month/city), which we denote by SD_Asking_{tc}. Following these steps, we generate an unbalanced panel of the variable SD_Asking_{tc} that consists of 72 city/month observations over the period January–March 2010 (pre-shock period) and 1,186 observations over the period November 2010–October 2013 (post-shock period).[28]

[26] Similar to the analysis above (again, see section 4), we condition the inclusion of city *c* at month *t* in our analysis here on experiencing no fewer than 30 asking prices for the couplet of *c* and *t*. This requirement allows us to include only post-January 2010 periods. Results, however, are robust to replacing the minimum 30-asking-price condition with 20, 40, and 50.

[27] The difference between average asking and closing prices (the latter presented in Table 1) is, among other things, due to the fact that the closing price figure is for the 2007–2013 period (while the asking price figure represents the 2010–2013 period).

[28] The derivation of both SD_Asking_{tc} and SD_{tc} in this section is based on the estimation of equation (2) for all couplets *t* and *c* (total of 1,258 estimations of equation [2]) with the explanatory variables *Rooms*, *Area*, *Floor*, and *Type*, as we do not observe additional asset amenities in our asking price sample. Also, note that 12 of the 48 participating cities satisfy the no-fewer-than-30-transactions condition in all 39 periods (months) and 28 cities in no fewer than 30 periods. Results, however, are robust to varying the minimum number of observations condition to 20, 40, and 50 transactions (results are not reported but are available on request).

The derivation of SD_Asking_{tc} is essentially similar to the derivation of SD_{tc} (the standard deviation of ε_{2itc} that follows from equation (2)—once again, see section 4 above), except for the fact that SD_{tc} is based on the computation of the standard deviation of $P_{itc} - \hat{P}_{itc}^{Close}$ rather than $P_{itc}^{Ask} - \hat{P}_{itc}^{Close}$. For each couplet t and c in the panel, we then compare between SD_Asking_{tc} and SD_{tc}. Note that $SD\_Asking_{tc} > SD_{tc}$ indicates that price dispersion of asking prices is greater than that of closing prices, implying that the public disclosure of closing price information conveys new information to the market over the information already inferred from asking prices. In contrast, $SD\_Asking_{tc} \leq SD_{tc}$ indicates that asking prices may be more informative than closing prices to buyers and sellers with regard to market prices (up to a possible constant difference between asking and closing prices).

Tables 7a and 7b present the results of a paired *t*-test for the difference between the means of SD_{tc} and SD_Asking_{tc} for the pre- and post-information shock periods, respectively. Empirical findings provide evidence to support an additional information effect generated by closing over asking prices. Specifically, the average values of SD_{tc} and SD_Asking_{tc} are equal to 0.21 and 0.24, respectively, over the post-price information shock period (the difference is significant at the 1%-level). Over the pre-price information shock period, the average values of SD_{tc} and SD_Asking_{tc} are equal to 0.23 and 0.24, respectively (difference is significant at the 10%-level). It thus follows that price dispersion of asking prices (particularly in the post-information shock period) is about 14% greater than that of closing prices, thus implying (as one might have expected) that the public disclosure of closing prices contains additional information that may not be inferred from asking prices. Moreover, it follows from the outcomes that while the standard deviation of closing prices decreases between pre- and post-price information shock periods, that of asking prices largely maintains the same level between these two periods.[29]

7. DOES INFORMATION EFFECT VARY WITH MARKET PARTICIPANT CHARACTERISTICS?

In the above analysis, we have provided evidence in support of improved information shock's effect on quality-adjusted price dispersion of housing transactions. A remaining

[29] The results for the post-price information shock period are robust to replacing the standard deviation measure with *P*75-*P*25 (*P*90-*P*10), the difference between the residuals in the 75th (90th) and the 25th (10th) percentiles (of $P_{itc}^{Ask} - \hat{P}_{itc}^{Close}$ and $P_{itc}^{Close} - \hat{P}_{itc}^{Close}$)—results are not reported but are available on request.

question, however, is whether the effect of the improved information shock varies with household characteristics such as education, income, and socio-economic status.

Intuitively, one may hypothesize either a positive or a negative correlation between those parameters and the extent of improved information effect. On the one hand, as transaction price information is now revealed to the public on the internet, one might expect that the information is better accessed in areas with a greater share of internet usage. Under the assumption that internet usage associates with more educated and wealthier households, a positive correlation is to be anticipated between the effect of the information shock and household income, education, and socio-economic status.

On the other hand, however, it might be the case that, even when formal price information was unavailable (i.e., prior to the information shock), wealthier and more educated households found the means to partially bridge the information shortage (through, for example, better availability and improved interpretation of asking prices). Hence, when information is now formally revealed, wealthier and more educated households' marginal benefit from the improved information is relatively limited, as compared to that of less privileged buyers and sellers. The latter, who previously were not only provided with no access to formal price information but also experienced very limited availability of indirect information, now have simple and direct access to all market price information; thus, their marginal benefit from the price information shock exceeds that of the more privileged households. Below we report on tests of whether the improved information shock varies with statistical area measures of household head's education, income, and socio-economic characteristics.[30]

We re-estimate equation (1a) where we interact the *Treatment* variable in the following form:

(1b)

$$SD_{\tau s} = \omega_0 + \omega_1 Treatment_\tau + \omega_2 Characteristic_s + \omega_3 Treatment_\tau \times Characteristic_s + \omega_4 N_{\tau s} + \omega_5 \Delta\hat{P}_{\tau s} + \omega_6 \left|\hat{\theta}_{6,ts}\right| + \omega_7 SD\_Stock_\tau + \vec{\omega}_8 Avg\_Attributes_{\tau s} + \vec{\omega}_9 Var\_Attributes_{\tau s} + \vec{\omega}_{10} Dum\_StatArea_s + \varepsilon_{5\tau s},$$

[30] As noted earlier, the socio-economic index is based on 16 statistical area indicators clustered into 4 groups: standard of living, employment and welfare, schooling and education, and demography. The scale for the socio-economic index ranges from -3 (lowest socio-economic level) to +3 (highest level) (see Israel Central Bureau of Statistics, 2013).

where $Characteristic$=(*School*, *Academic*, *Income, SocioEcon*) and where *School* stands for the average number of years of schooling for household head in a statistical area; *Academic* is the percent of household heads holding an academic degree in a statistical area; *Income* is the average monthly income per standard person in a statistical area;[31] and *SocioEcon* is a statistical area's score on the socio-economic index.

Table 8 presents the outcomes from the estimation of equation (1b) with each of the household characteristics in the market. Those results offer evidence of significant variation in the effects of information shock across household characteristics in the statistical area. For all four interaction terms, the coefficient ω_3 is positive and significant at the 1% level, while ω_1 and ω_2 are negative and significant at the 1% level (see columns 1–4 in Table 8). Results thus imply that while the examined household characteristics inversely correlate with price dispersion in the pre-information shock period, this correlation was significantly moderated following the information shock. In other words, the information shock effect is particularly meaningful in the less privileged statistical areas.

Specifically, Figures 3A–6A (3B–6B) display the marginal effect of the information shock (i.e., when *Treatment*=1) on price dispersion for different levels (percentiles) of the interaction variable in the sample. It follows that the average number of years of schooling of household heads in a statistical area (*School*) moderates the improved information shock effect. That is, while information shock for average number of years of schooling equal to 10.5 associates with a 23% decrease in price dispersion (from *SD*=0.172 to *SD*=0.132), the effect is only a 9.4% decrease (from 0.137 to 0.124) for average number of years of schooling equal to 16.7. Consistently, the percentage of academic degree holders among household heads in a statistical area (*Academic*) moderates the improved information shock effect: while information shock associates with a decreased price dispersion of about 21% (from 0.165 to 0.130) in a statistical area with 5% academic degree holders, the information shock effect decreases to only 8% (from *SD*=0.136 to *SD*=0.125) in statistical areas with 75% academic degree holders. We also find that average income per standard person negatively correlates with the information

[31] The average monthly income per *standard person* is the single income measure per statistical area published by the Israel Central Bureau of Statistics. This measure assesses the standard of living of households with varying number of persons [see Israel Central Bureau of Statistic (2013)].

shock effect: while information shock in a statistical area with average monthly income per standard person equal to about $550 associates with about a 20% decrease in price dispersion (from 0.164 to 0.131), the effect is only 7.6% (from 0.134 to 0.124) in a statistical area with average monthly income per standard person equal to about $3,400. In other words, for every $230 decrease in monthly income per standard person, the improved information shock associates with an additional 1% average decrease in the price dispersion. Finally, a market with a greater score on the socio-economic index associates with a diminished information shock effect: While improved information shock associates with a decreased price dispersion of about 22% (from 0.164 to 0.128) in a statistical area with a socio-economic index score equal to -1.5, the effect is only 10.1% (from 0.141 to 0.128) in statistical areas with a score of 2.5 on the socio-economic scale.[32]

These findings thus indicate that the major beneficiaries of the improved information shock are sellers and buyers transacting in markets where households exhibit relatively low levels of education, income, and socio-economic characteristics. These outcomes are consistent with the notion that market participants in less privileged regions, having limited access to means that may overcome information shortage, are the main beneficiaries of improved public information, while in areas with a more educated, wealthier, and generally higher socio-economic population, transactions involve greater information even when it is not formally available.

8. SUMMARY AND CONCLUSIONS

This research provides new empirical evidence on the effect of information shock on quality-adjusted housing price dispersion. The analysis examines a unique Israeli experience wherein the Tax Authority was court-ordered to publicly disclose information on all past and current real estate transactions.

[32] We have also attempted to interact *Treatment* with the rate of internet usage in a statistical area. The outcomes, however, are similar to those obtained for the other statistical area characteristics. This could be explained by the fact that (*a*) internet usage rate is highly correlated with all four examined *Characteristic* variables (with a maximal Pearson correlation equal to 0.82 with *SocioEcon*); (*b*) while the new information on housing closing prices is available on the internet, internet usage index might not be a good proxy for actual use of the new information, as individuals may now indirectly obtain and make use of this information relying on sources such as real estate agents, other internet users, etc.

Statistical findings provide solid evidence in support of improved information effect on the dispersion of transaction prices. Standard deviation of quality-adjusted prices has decreased by about 17% subsequent to the improved information shock. Further, we find evidence that information effect varies with market characteristics. Research findings provide real-world evidence suggesting the importance of price transparency in a market where transactions involve significant and long-term individual economic consequences.

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Table 1: List of Micro-Level Variables, Description, and Summary Statistics

Variable	Description	Avg.	Std.	Min	Max
P	Transaction closing price (in USD)	278,671	197,144	10610	4,986,737
Room	Total number of rooms	3.66	1.06	2	10
Area	Floor area (in square feet)	953.74	384.17	323	3229
Age	The age of the structure (in years) at the time of the transaction	25.05	17.78	0	100
Floor	The story on which the asset is located in the structure	1.90	2.22	0	32
Dum_New	Dummy variable equals 1 if *Age* is less than 1 (i.e., new asset); 0 otherwise	0.101	0.302	0	1
SocioEcon	Socio-economic index score of the statistical area where the asset is located	0.272	0.819	-2.462	2.893
*Type*1	Dummy variable equals 1 if the asset is a condominium apartment (base category)	0.949	0.218	0	1
*Type*2	Dummy variable equals 1 if the asset is a ground-level apartment; 0 otherwise	0.007	0.082	0	1
*Type*3	Dummy variable equals 1 if the asset is a penthouse or a duplex apartment; 0 otherwise	0.003	0.053	0	1
*Type*4	Dummy variable equals 1 if the asset is a townhouse; 0 otherwise	0.003	0.051	0	1
*Type*5	Dummy variable equals 1 if the asset is an attached unit; 0 otherwise	0.023	0.152	0	1
*Type*6	Dummy variable equals 1 if the asset is a style 1 detached unit; 0 otherwise	0.010	0.100	0	1
*Type*7	Dummy variable equals 1 if the transacted property is a style 2 detached unit; 0 otherwise	0.004	0.062	0	1
Month	A trend variable that respectively equals 1,…,12 for each month within each chronological year prior and subsequent to the information shock [see equation (2a)]	6.38	3.42	1	12

Table 2: List of City-Level Panel Variables, Description, and Summary Statistics

Variable	**Description**	**Avg.**	**Std.**	**Min**	**Max**
$Treatment_t$	Dummy variable that equals 1 for periods subsequent to information disclosure (i.e., subsequent to October 2010)	0.507	0.500	0	1
$\Delta SD\_\hat{P}_{tc}$	First difference in 6-month (ending at *t*) moving standard deviation of quality-adjusted housing prices in city *c*	$-7.8\text{x}10^{5}$	0.009	-0.059	0.077
$\Delta\hat{P}_{tc}$	6-month (ending at *t*) rate of change in quality-adjusted housing prices in city *c*	0.049	0.061	-0.190	0.351
N_{tc}	The number of transactions in period *t* and city *c*	100.7	82.4	31	838
ΔSD_Stock_t	First difference of 3-month moving standard deviation of daily yields of the Tel-Aviv100 stock index	-0.0001	0.002	-0.0061	0.0073
Avg_Area_{tc}	The average area (in square feet) of assets transacted in period *t* and city *c*	962.73	135.89	615	1473
Avg_Rooms_{tc}	The average number of rooms of assets transacted in period *t* and city *c*	3.70	0.36	2.50	4.82
Avg_Floor_{tc}	The average story of assets transacted in period *t* and city *c*	1.85	0.50	0.19	3.78
Avg_Age_{tc}	The average age (in years) of assets transacted in period *t* and city *c*	24.15	7.44	3.70	43.29
$Avg\_SocioEcon_{tc}$	The average score on the socio-economic index of the statistical area where the asset is located	0.27	0.62	-1.30	1.90
SD_Area_{tc}	The standard deviation of the area (in square feet) of assets transacted in period *t* and city *c*	358.5	80.4	151.2	734.6
SD_Rooms_{tc}	The standard deviation of the number of rooms of assets transacted in period *t* and city *c*	0.99	0.13	0.51	1.55
SD_Floor_{tc}	The standard deviation of the story of assets transacted in period *t* and city *c*	2.08	0.54	0.69	5.76
SD_Age_{tc}	The standard deviation of the age of assets transacted in period *t* and city *c*	15.19	3.29	1.43	24.25
$SD\_SocioEcon_{tc}$	The standard deviation of the score on the socio-economic index of the statistical area where the asset is located	0.49	0.19	0.13	1.02
SD_{tc}	Standard deviation of the residuals from the estimation of the price equation (2)	0.184	0.054	0.069	0.412
$P75 - P25_{tc}$	Difference between the residuals in the 75^{th} and the 25^{th} percentiles	0.223	0.076	0.047	0.542

Notes: Housing transaction data provided by the Israel Tax Authority; stock price data provided by the Tel Aviv Stock Exchange; all other data provided by the Israel Central Bureau of Statistics.

Table 3: Regression Results for the City-Level Estimation of Equation (1)

Column	(1)	(2)	(3)	(4)
Dependent variable	*SD*	*SD*	*P*75-*P*25	*P*75-*P*25
# of months prior and subsequent to the treatment	36 months	12 months	36 months	12 months
Constant	0.198^{***} (0.026)	0.088^{**} (0.042)	0.194^{***} (0.046)	0.026 (0.059)
$Treatment_t$	-0.031^{***} (0.003)	-0.015^{***} (0.003)	-0.039^{***} (0.004)	-0.017^{***} (0.005)
N_{tc}	-0.0001 (0.0001)	0.0000 (0.0000)	0.0002 (0.0002)	0.0004 (0.003)
$\Delta\hat{P}_{tc}$	-0.022^{**} (0.010)	-0.025 (0.024)	-0.041^{**} (0.017)	-0.033 (0.036)
$SD\_\hat{P}_{ct}$	0.010 (0.073)	-0.134 (0.092)	0.009 (0.102)	-0.198^{*} (0.115)
SD_Stock_t	-0.802^{***} (0.257)	-1.152^{*} (0.666)	-0.831^{**} (0.391)	-1.892^{**} (0.916)
$Avg\_Attributes_{ct}$	Included	Included	Included	Included
$SD\_Attributes_{ct}$	Included	Included	Included	Included
Dum_City (city fixed-effect)	Included	Included	Included	Included
# of Observations	2475	842	2475	842
# of Cities	45	42	45	42
R^2 (within cities)	0.260	0.093	0.199	0.091
Prob> F	0.0000	0.0000	0.0000	0.0000
Spatial unit	City	City	City	City
Temporal unit	Month	Month	Month	Month

Notes: Table 3 presents results of OLS estimation of equation (1) with robust standard errors. We reject the homoskedasticity assumption in (1) (Chi2 (42) = 1155.49; *p*-value<0.0001), while we cannot reject the no-serial correlation assumption in (1) (Wooldridge test generate F-statistic (1,39) = 0.979; *p*-value = 0.328). Results are robust to maximum likelihood procedure, where each city is weighted by the number of transactions. Columns (1) and (3) [(2) and (4)] present estimation results for the period that includes 36 (12) months prior and subsequent to the information shock. Columns (3) and (4) further present estimation results when *P*75-*P*25 replaces *SD* on the left-hand side of equation (1). Results are further robust to: (*a*) the omission of the city fixed-effect variable (*Dum_City*) and the omission of the average attributes ($Avg\_Attributes$) and their standard deviation (*SD_Attributes*); (*b*) the substitution of the left-hand side variable with its natural logarithm; (*c*) the substitution of the left-hand side variable in equation (1) with either *P*90-*P*10 or *Pmax-Pmin*, i.e., the difference between the 90th and the 10th percentile or the maximum and minimum, respectively, of the residuals from the estimation of (2); (*d*) including only the 10, 20, and 30 most active cities in the sample; (*e*) excluding the 10, 20, and 30 most active (transaction-wise) cities from the sample; (*f*) changing the condition for city/month participation in the estimation from 30 transactions to either 20, 40, or 50 transactions; and (*g*) omitting transactions of new properties from the sample. Robust standard errors are provided in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively.

Table 4: List of Statistical Area-Level Panel Variables, Description, and Summary Statistics

Variable	Description	Avg.	Std.	Min	Max
$Treatment_{\tau}$	Dummy variable that equals 1 for periods subsequent to information disclosure (i.e., subsequent to October 2010)	0.501	0.500	0	1
$SD_{\tau s}$	The standard error of the residuals in price equation (2)	0.142	0.048	0.035	0.356
$P75-P25_{\tau s}$	Difference between the residuals in the 75th and 25th percentiles	0.169	0.065	0.046	0.510
$N_{\tau s}$	The number of transactions in period τ and statistical area *s*	57.4	31.3	31	395
$Avg\_Area_{\tau s}$	The average area (in square feet) of assets transacted in period τ and statistical area *s*	918.1	205.6	480.8	1846
$Avg\_Rooms_{\tau s}$	The average number of rooms of assets transacted in period τ and statistical area *s*	3.58	0.57	2.18	5.88
$Avg\_Floor_{\tau s}$	The average story of assets transacted in period τ and statistical area *s*	2.08	1.00	0	9.33
$Avg\_Age_{\tau s}$	The average age (in years) of assets transacted in period τ and statistical area *s*	26.1	13.0	0.1	59.5
$SD\_Area_{\tau s}$	The standard deviation of the area (in square feet) of assets transacted in period τ and statistical area *s*	24.73	8.50	8.07	64.31
$SD\_Rooms_{\tau s}$	The standard deviation of the number of rooms of assets transacted in period τ and statistical area *s*	0.83	0.19	0.33	1.84
$SD\_Floor_{\tau s}$	The standard deviation of the story of assets transacted in period τ and statistical area *s*	1.87	0.82	0.00	9.81
$SD\_Age_{\tau s}$	The standard deviation of the age of assets transacted in period τ and statistical area *s*	9.76	5.73	0.38	30.07
$\Delta\hat{P}_{\tau s}$	The annual rate of change in a quality-adjusted asset (log) price in period τ and statistical area *s*	0.099	0.167	-1.84	1.51
SD_Stock_{τ}	1-year moving standard deviation of daily yields of the Tel Aviv 100 stock index	-0.001	0.005	-0.008	0.008
$SocioEcon_{s}$	The score of statistical area *s* on the socio-economic index	0.34	0.78	-1.93	2.76
$Schooling_{s}$	Average years of schooling of household heads aged 25–54 in statistical area *s*	13.96	1.34	7.72	17.25
$Academic_{s}$	Percent of household heads aged 25–54 holding an academic degree in statistical area *s*	34.73	17.15	2.96	80.83
$Income_{s}$	Average monthly income per standard person in statistical area *s* (in dollars)	1,520	556	344	4606

Notes: Transaction price data provided by the Israel Tax Authority; stock price data provided by the Tel Aviv Stock Exchange; all other data provided by the Israel Central Bureau of Statistics. The variables Avg_Area_{tc}, Avg_Rooms_{tc}, Avg_Floor_{tc}, and Avg_Age_{tc} appear in equation (1) as the vector $Avg\_Attributes_{tc}$ and SD_Area_{tc}, SD_Rooms_{tc}, SD_Floor_{tc}, and SD_Age_{tc} appear as the vector $SD\_Attributes_{tc}$ in (1).

Table 5: Regression Results for the Statistical Area-Level Estimation of Equation (1a)

Column	(1)	(2)	(3)	(4)
Dependent variable	*SD*	*SD*	*P*75-*P*25	*P*75-*P*25
# of years prior and subsequent to the treatment	3 years	1 year	3 years	1 year
Constant	0.097*** (0.019)	0.029 (0.063)	0.119*** (0.025)	0.032 (0.090)
Treatment	-0.024*** (0.001)	-0.016*** (0.003)	-0.028*** (0.002)	-0.018*** (0.004)
N_τ	7.5×10^{-5}*** (2.8×10^{-5})	-6.8×10^{-5} (6.9×10^{-5})	2.5×10^{-5} (3.9×10^{-5})	-0.0002** (0.0001)
$\lvert\hat{\theta}_{6,ts}\rvert$	0.310*** (0.087)	0.411** (0.184)	0.424*** (0.110)	0.643** (0.285)
$\Delta\hat{P}_{\tau s}$	-0.003 (0.003)	-0.003 (0.007)	-0.003 (0.004)	-0.014 (0.012)
ΔSD_Stock_τ	0.821*** (0.100)		1.228*** (0.148)	
$Avg\_Attributes_{s\tau}$	Included	Included	Included	Included
$SD\_Attributes_{s\tau}$	Included	Included	Included	Included
Dum_StatArea	Included	Included	Included	Included
Number of Observations	2991	892	2991	892
Number of statistical areas	608	446	608	446
R^2 (within statistical areas)	0.230	0.170	0.182	0.139
Prob>chi2	0.0000	0.0000	0.0000	0.0000
Spatial unit	Statistical Area	Statistical Area	Statistical Area	Statistical Area
Temporal unit	Year	Year	Year	Year

Notes: Table 5 presents results of OLS estimation of equation (1a). We use clustered standard errors in columns (1) and (3) as we reject the homoskedasticity and the no-serial correlation assumptions. We use robust standard errors in columns (2) and (4) as we reject the homoskedasticity assumption while we do not reject the no-serial correlation assumption (test results are not reported but are available upon request). Also, results are robust to WLS procedure where each statistical area is weighted by the number of transactions. Columns (1) and (3) [(2) and (4)] present estimation results for the period that includes 36 (12) months prior and subsequent to the information shock. Columns (3) and (4) further present estimation results when *P*75-*P*25 replaces *SD* on the left-hand side of equation (1). Results are further robust to the substitution of the left-hand variable with its natural logarithm or with either *P*90-*P*10 or *Pmax-Pmin*, i.e., the difference between the 90th percentile and the 10th percentile, or the difference between the maximum and the minimum of the residuals from equation (2). The explanatory variable SD_Stock_t is omitted from the estimation of which outcomes are presented in columns (3) and (4), as it only includes one year prior and subsequent to the information shock, and thus SD_Stock_t becomes multicolinear with *Treatment*. Respective clustered and robust standard errors are provided in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively.

Table 6: List of Micro-Level Variables, Description, and Summary Statistics of Asking Prices

Variable	Description	Avg.	Std.	Min	Max
P	Asking price (in USD)	346,760	196,002	12,452	1,461,907
$Room$	Total number of rooms	3.65	0.89	2	10
$Area$	Floor area (in square feet)	1022.6	303.8	323	3229
$Floor$	The story on which the asset is located in the structure	3.16	2.66	0	20

Notes: Table 6 presents summary statistics of the sample of asking prices. We omit from the sample observations with prices below 50K new Israeli shekels (about 13.5K dollars) and above 5,000K shekels (1,350K dollars); below 2 and above 10 rooms (including a living room); and below 300 and above 3,000 square-feet. The test thus includes about 95% of the raw sample. Test results, however, are robust to using the raw data without omitting observation.

Table 7a: Results of a Paired Mean Comparison *t*-Test Prior to Information Shock

Variable	**Obs.**	**Mean**	**Std. Err.**	**Std. Dev.**	**[95% Conf. Interval]**	
SD_{tc}	72	0.2317	0.0079	0.0677	0.2158	0.2476
SD_Asking_{tc}	72	0.2430	0.0108	0.0915	0.2215	0.2645
$SD_{tc} - SD\_Asking_{tc}$	72	-0.0113	0.0069	0.0588	-0.0251	0.0024

H_0: $mean(SD_{tc} - SD\_Asking_{tc}) = 0$ *t*=-1.6366 *df*=71

H_1 (1): $mean(SD_{tc} - SD\_Asking_{tc}) < 0$ *Prob(T<t)=0.0531*
H_1 (2): $mean(SD_{tc} - SD\_Asking_{tc}) \neq 0$ *Prob(|T|>|t|)=0.1061*
H_1 (3): $mean(SD_{tc} - SD\_Asking_{tc}) > 0$ *Prob(T>t)=0.9469*

Table 7b: Results of a Paired Mean Comparison *t*-Test Subsequent to Information Shock

Variable	**Obs.**	**Mean**	**Std. Err.**	**Std. Dev.**	**[95% Conf. Interval]**	
SD_{tc}	1,186	0.2124	0.0017	0.0610	0.2090	0.2159
SD_Asking_{tc}	1,186	0.2438	0.0020	0.0682	0.2400	0.2477
$SD_{tc} - SD\_Asking_{tc}$	1,186	-0.0314	0.0017	0.0604	-0.0348	-0.0279

H_0: $mean(SD_{tc} - SD\_Asking_{tc}) = 0$ *t*=-17.901 *df*=1185

H_1 (1): $mean(SD_{tc} - SD\_Asking_{tc}) < 0$ *Prob(T<t)<0.0001*
H_1 (2): $mean(SD_{tc} - SD\_Asking_{tc}) \neq 0$ *Prob(|T|>|t|)<0.0001*
H_1 (3): $mean(SD_{tc} - SD\_Asking_{tc}) > 0$ *Prob(T>t)>0.9999*

Notes: Tables 7a and 7b present paired *t*-test results for a mean comparison between SD_{tc} and SD_Asking_{tc} prior and subsequent to the information shock, respectively. We omit *c* and *t* couplets for which the number of closing and/or asking prices is less than 30. Results, however, are robust to changing the threshold number to 20, 40, or 50. Results presented in Table 7b are robust for replacing SD_{tc} and SD_Asking_{tc} with *P*75-*P*25 and P90-P10 as as alternative measures of the price dispersion (results are available upon request).

Table 8: Regression Results for the Interaction Estimation of Equation (1b)

Column	(1)	(2)	(3)	(4)
	Characteristic = School	***Characteristic = Academic***	***Characteristic = Income***	***Characteristic = SocioEcon***
Constant	0.138*** (0.017)	0.074*** (0.013)	0.078*** (0.013)	0.065*** (0.013)
$Treatment$	-0.085*** (0.010)	-0.037*** (0.002)	-0.038*** (0.003)	-0.027*** (0.001)
$Characteristic$	-0.006*** (0.001)	-0.0004*** (0.0001)	$-2.7\text{x}10^{6}$*** ($6\text{x}10^{7}$)	-0.006*** (0.002)
$Treatment \times Characteristic$	0.004*** (0.001)	0.0003*** (0.0001)	$1.6\text{x}10^{-6}$*** ($4.2\text{x}10^{-7}$)	0.006*** (0.001)
N_t	0.0001*** (0.00003)	0.0001*** (0.00003)	0.0001*** (0.00003)	0.0001*** (0.00003)
$\lvert\hat{\theta}_{6,ts}\rvert$	0.437*** (0.074)	0.440*** (0.074)	0.446*** (0.074)	0.447*** (0.074)
$\Delta\hat{P}_{\tau s}$	-0.001 (0.003)	-0.001 (0.003)	-0.001 (0.003)	-0.001 (0.003)
ΔSD_Stock_t	0.978*** (0.099)	0.977*** (0.099)	0.971*** (0.099)	0.975*** (0.099)
$Avg\_Attributes_{ct}$	Included	Included	Included	Included
$SD\_Attributes_{ct}$	Included	Included	Included	Included
Dum_StatArea	Not Included	Not Included	Not Included	Not Included
# of Observations	2991	2991	2991	2991
# of statistical areas	608	608	608	608
R^2 (within statistical areas)	0.233	0.233	0.229	0.229
Prob>chi2	0.0000	0.0000	0.0000	0.0000
# of years prior and subsequent to the treatment	3 years	3 years	3 years	3 years
Spatial unit	Statistical Area	Statistical Area	Statistical Area	Statistical Area
Temporal unit	Year	Year	Year	Year

Notes: Standard errors in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively. Results are robust to the omission of observations in which the *Characteristic* variable is in the top and bottom 5% or top and bottom 10% of its distribution.

Figure 1A: Google Trend's Search Interest in "Apartment Prices Tax Authority," January 2007 to December 2014

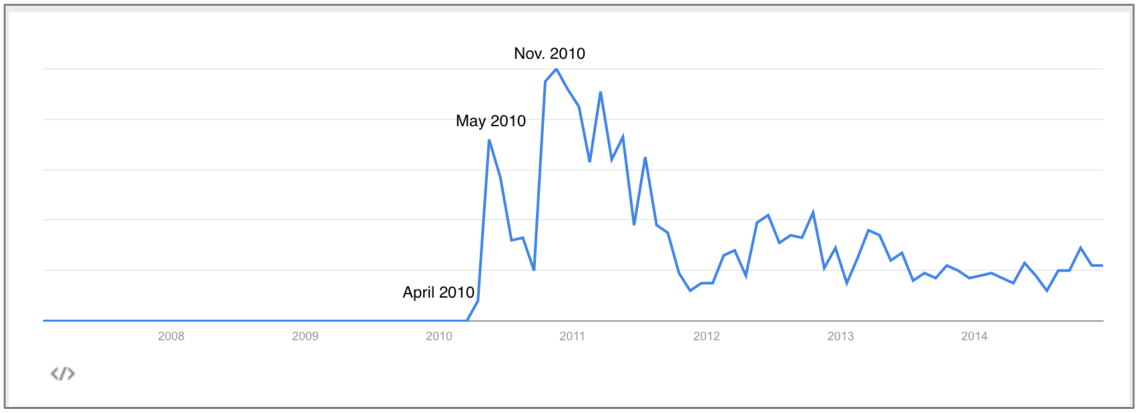


Figure 1B: Google Trend's Search Interest in "Real Estate Information," January 2007 to December 2014

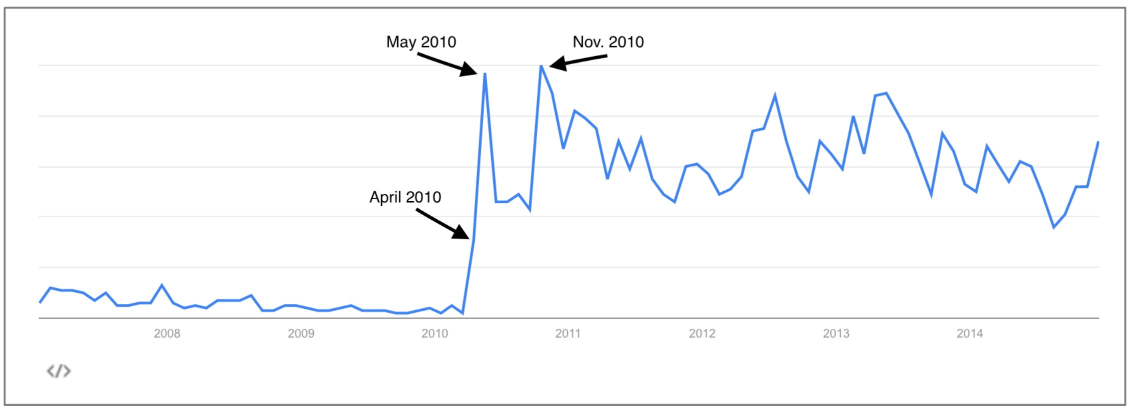


Figure 1B: Google Trend's Search Interest in "Apartment Prices," January 2007 to December 2014

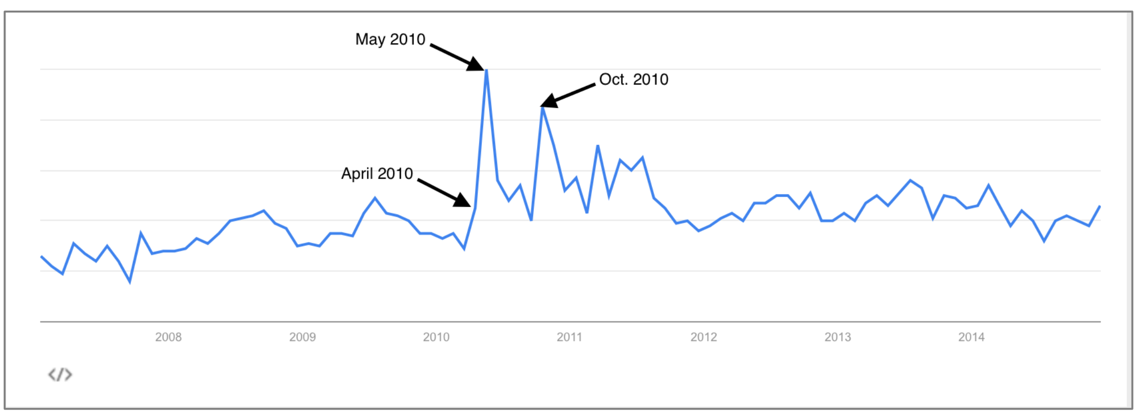


Figure 2: Estimated Coefficient on the *Treatment* Variable in the 45 Placebo Treatment Estimations Over the Period January 2000 – March 2010

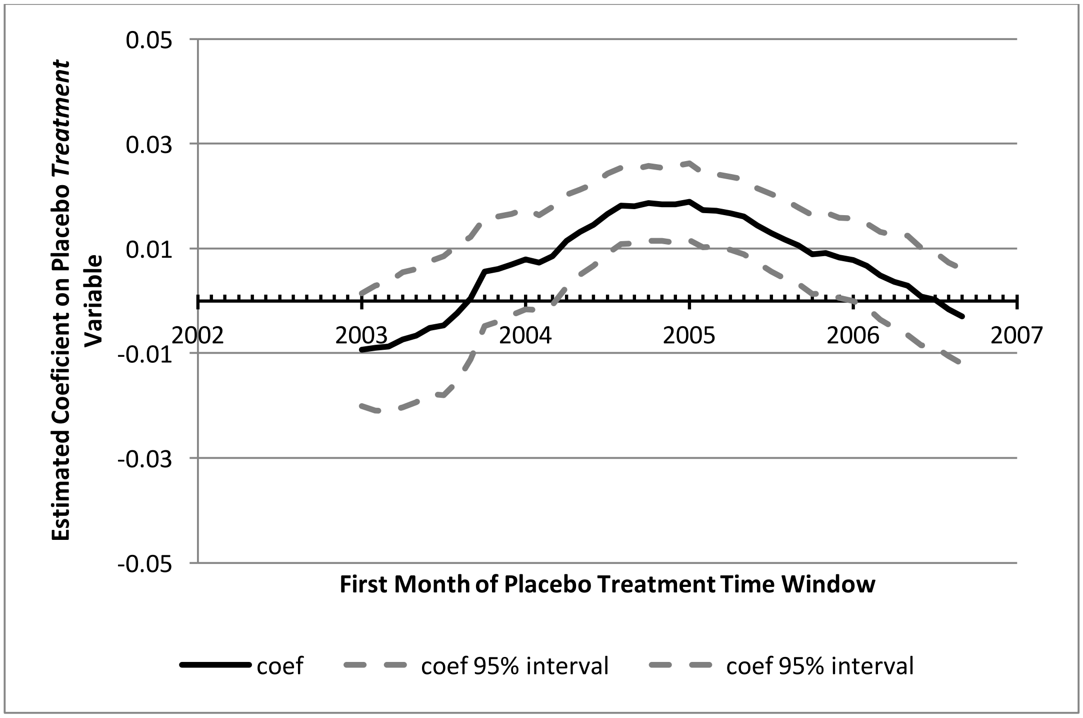


Figure 3A: The Effect of Information Shock on Price Dispersion for Different Levels of Average Number of Years of Household Head Schooling in a Statistical Area

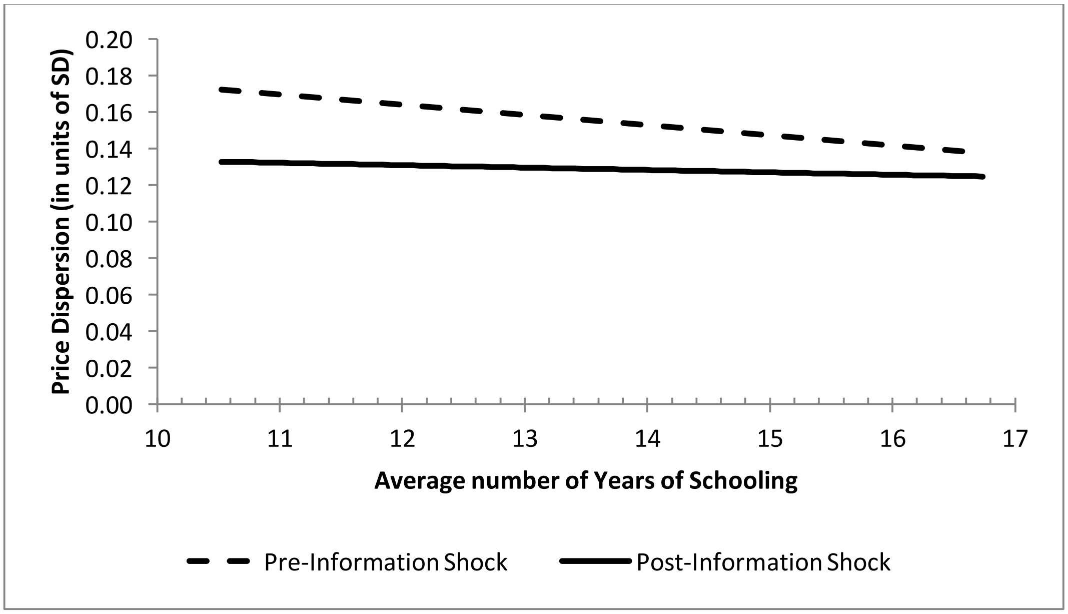


Figure 3B: The Effect of Information Shock on Price Dispersion for Different Percentiles of Average Number of Years of Household Head Schooling in a Statistical Area

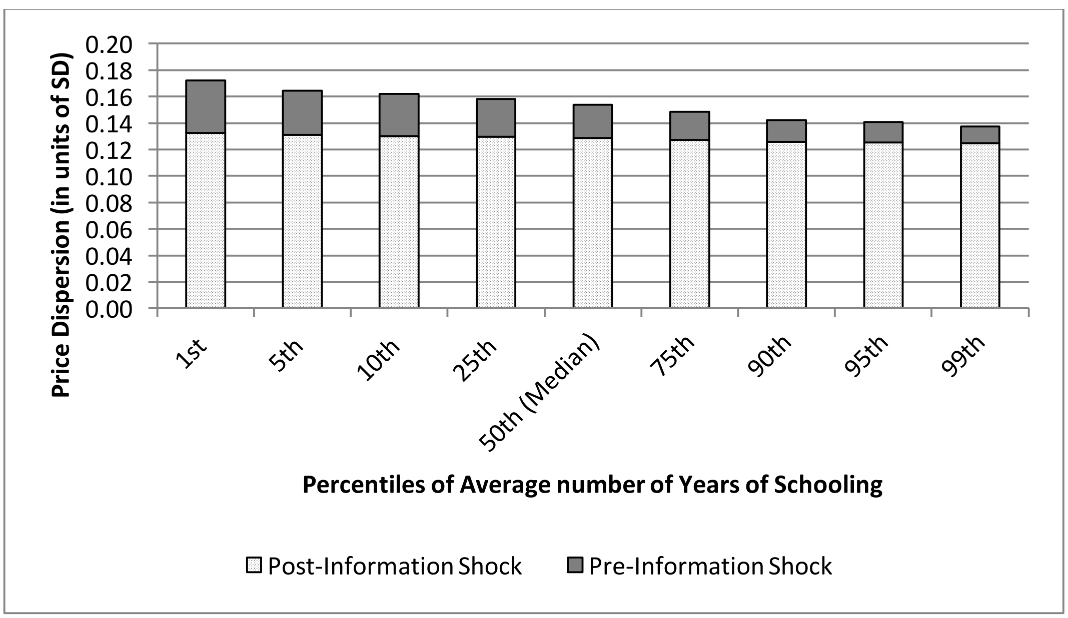


Figure 4A: The Effect of Information Shock on Price Dispersion for Different Percentages of Household Heads Holding Academic Degree in a Statistical Area

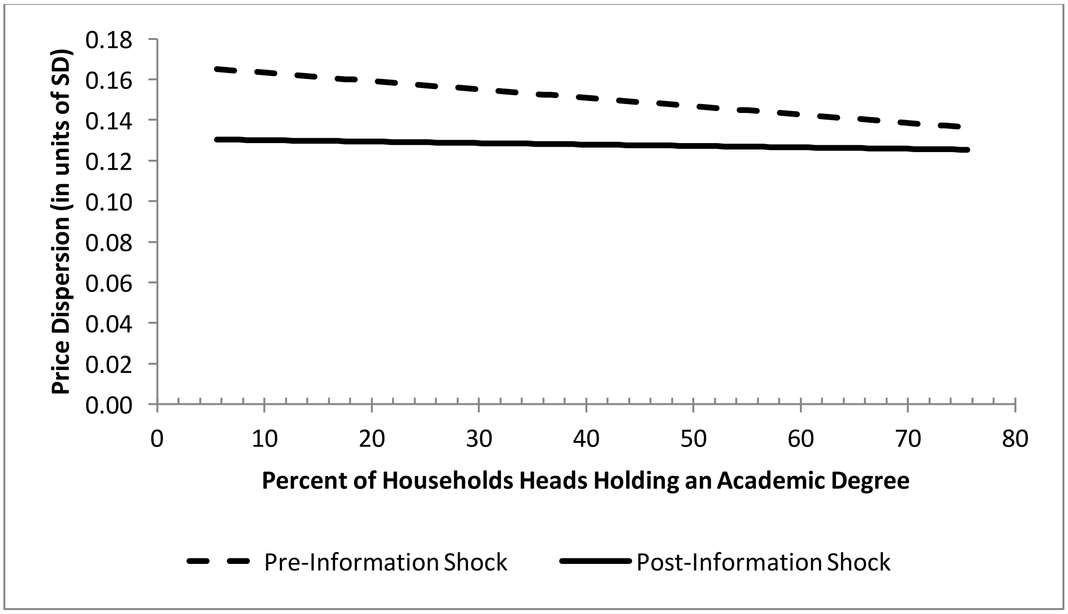


Figure 4B: The Effect of Information Shock on Price Dispersion for Different Percentiles of the Share of Household Heads Holding Academic Degree in a Statistical Area

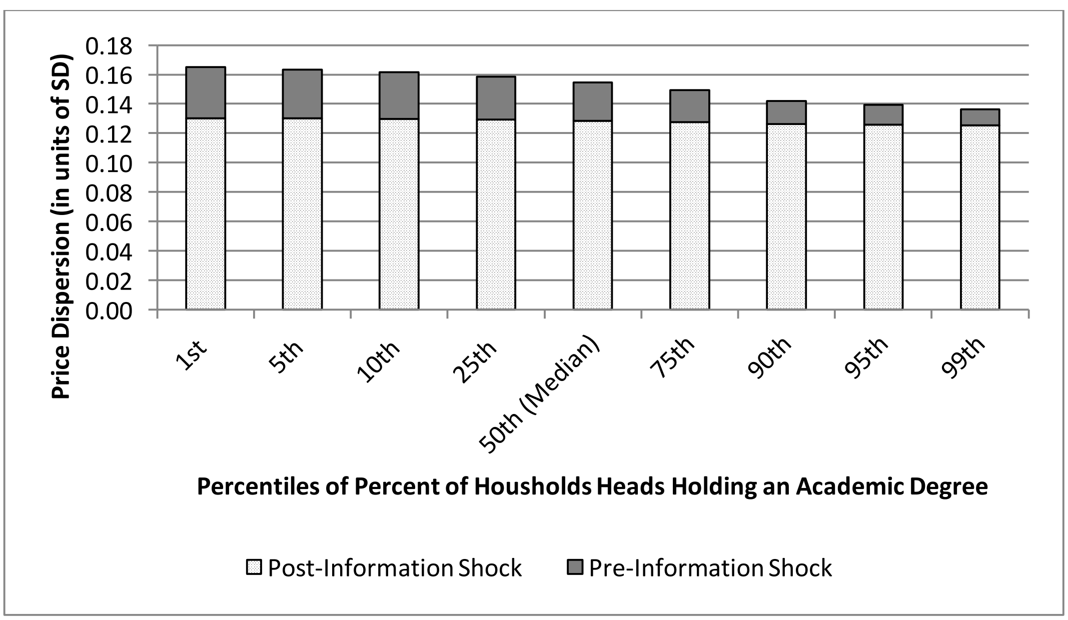


Figure 5A: The Effect of Information Shock on Price Dispersion for Different Levels of Average Income Per Standard Person in a Statistical Area

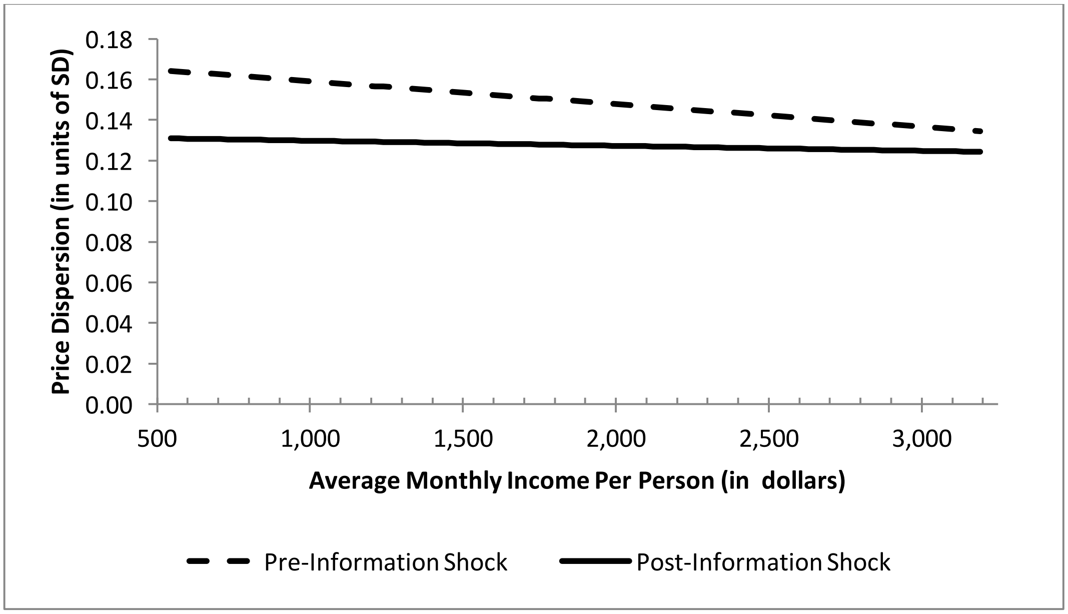


Figure 5B: The Effect of Information Shock on Price Dispersion for Different Percentiles of Average Income Per Standard Person in a Statistical Area

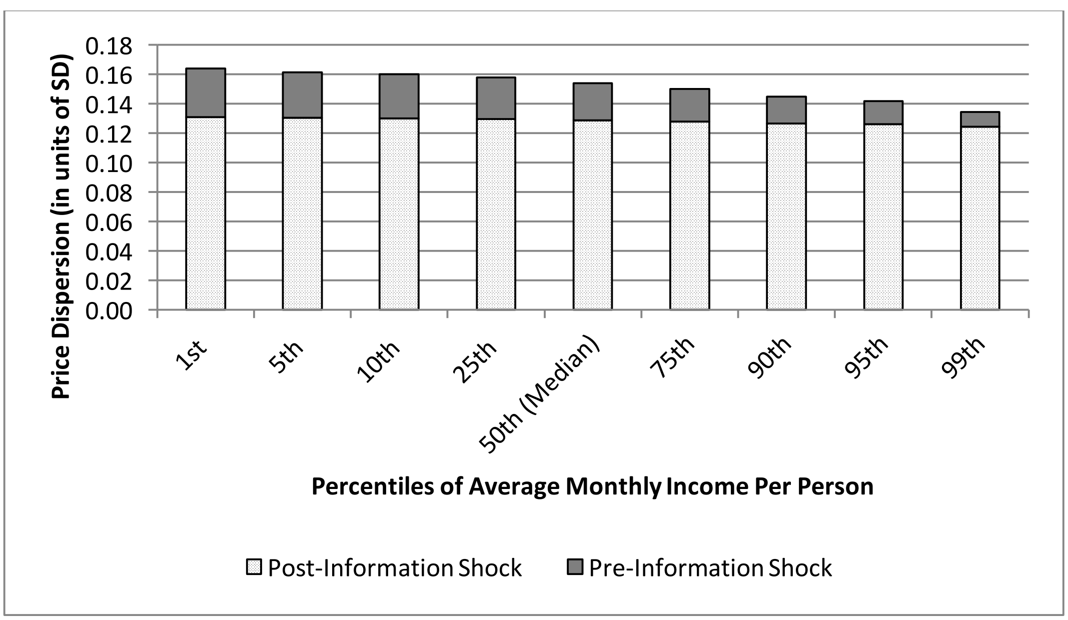
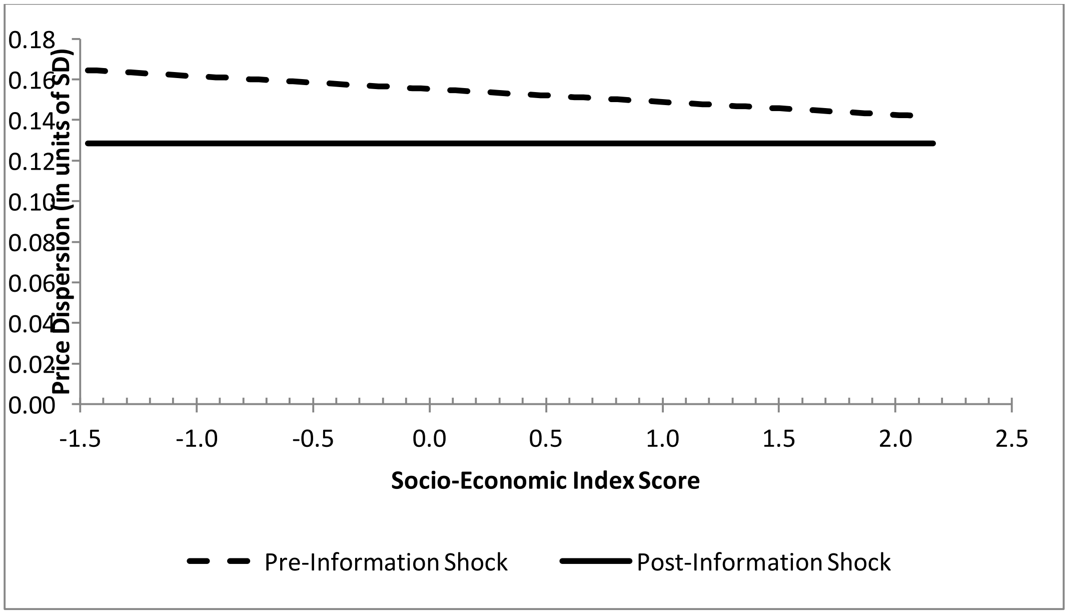
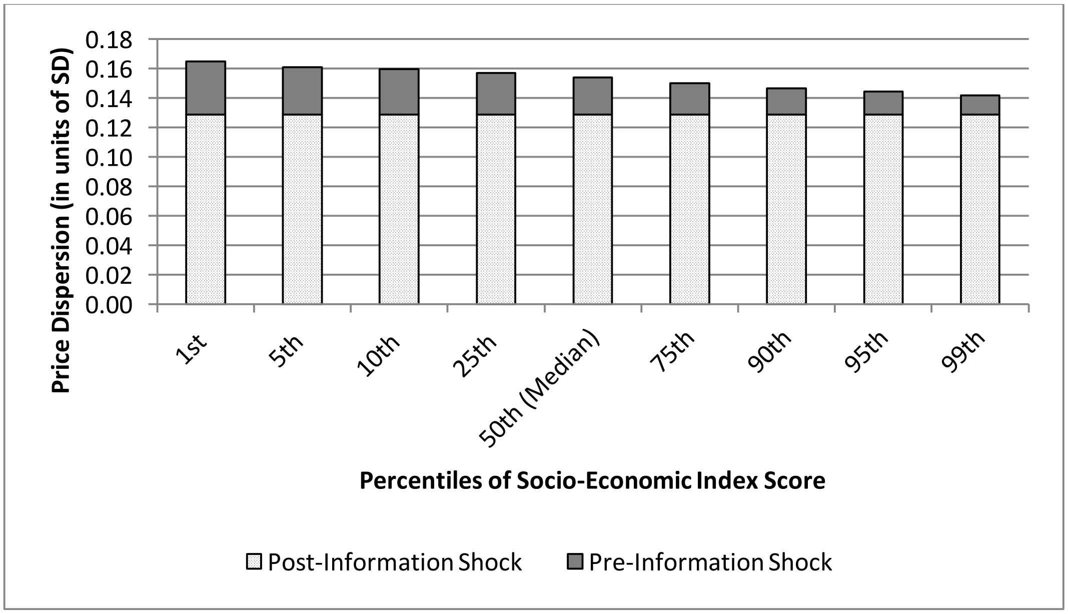


Figure 6A: The Effect of Information Shock on Price Dispersion for Different Scores on the Socio-Economic Index of Statistical Area



Notes: Figures 3A–6A display the effect of the information shock on price dispersion for different levels of the interaction variables: *School* (Figure 3A), *Academic* (Figure 4A), *Income* (Figure 5A) and *SocioEcon* (Figure 6A). The solid (scattered) line presents the predicted standard deviation of the residuals, *SD*, that follows from the estimation of equation (1b), subsequent (prior) to the information shock. Values of the interaction variable on the X-axis range from the 1st to the 99th percentile of the interaction variable in the sample.

Figure 6B: The Effect of Information Shock on Price Dispersion for Different Percentiles of the Socio-Economic Index Scores of Statistical Area



Notes: Figures 3B–6B display the effect of the information shock on price dispersion for different percentiles of the interaction variables: *School* (Figure 3B), *Academic* (Figure 4B), *Income* (Figure 5B), and *SocioEcon* (Figure 6B). The lower/lighter section of each bar depicts the estimated standard deviation of the residuals, *SD*, subsequent to the information shock. The darker section of each bar represents the decrease in price dispersion associated with the information shock.

Appendix A

Derivation of $SD\_\hat{P}_{tc}$, $\Delta\hat{P}_{tc}$, *and* $\Delta\hat{P}_{\tau s}$

For each city *c* in the sample we estimate:

(A1)

$$\ln(P_{ic}) = \gamma_{0,c} + \gamma_{1c}\ln(Room_{itc}) + \gamma_{2c}\ln(Area_{itc}) + \gamma_{3c}\ln(Age_{itc}) + \gamma_{4c}\ln(Floor_{itc}) + \gamma_{5c}Dum\_New_{itc} + \gamma_{6c}SocEcon_{ic} + \vec{\gamma}_{7c}TYPE_{itc} + \vec{\gamma}_{8ic}D_{it} + \varphi_{ic} \text{ for all } c,$$

where *D* is a time fixed-effect; $\gamma_{0c} - \gamma_{6c}$ and $\vec{\gamma}_{7,c} - \vec{\gamma}_{8,ic}$ are estimated parameters and vectors of parameters, respectively; φ_{ic} is a random disturbance term; and all other variables are as described before.[33]

The price equation (1A) is estimated once for each city (altogether 42 estimations whose average R^2 is 0.839, with a minimum of 0.656 and a maximum of 0.902). By substituting the average value for each variable in the entire sample on the right-hand side of (1A), we produce a price index for each city by which we compute the 6-month (ending at *t*) rate of change in quality-adjusted housing prices in city *c*, $\Delta\hat{P}_{tc}$, and the standard deviation (over a six-month period ending at *t*) of the rate of change in the quality-adjusted price, $SD\_\hat{P}_{tc}$, to be put on the right-hand side of equation (1).

We use a similar method (with the adjustment of *c* to *s* and *t* to *τ*) in order to generate $\Delta\hat{P}_{\tau s}$, to be put on the right-hand side of equation (1a).

[33] We generate $SD\_\hat{P}_{tc}$ by estimating equation (A1) with a time fixed-effect for city *c* [rather than by estimating equation (2) above for all *t* and *c*] so as to avoid the loss of panel observations of $SD\_\hat{P}_{tc}$ that would follow cases where the couplet *t* and *c* exhibits a small number of transactions. Results, however, are robust to deriving $SD\_\hat{P}_{tc}$ using equation (2) (not reported but available upon request).