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Estimating financial information asymmetry in real estate transactions in China: An application of two-tier frontier model

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Estimating financial information asymmetry in real estate transactions in China: An application of two-tier frontier model

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Abstract:

This study applies the two-tier stochastic frontier model to estimate the distribution of housing transaction information in Hangzhou, Wenzhou, Ningbo, and Jinhua (four cities in Zhejiang Province, China) during the year 2018, to analyze the difference in the price information acquired by the buyers and sellers in the transaction, and the effect of information asymmetry on the transaction price. The empirical results show that in each city, during the housing transaction process, the supplier has more complete information about house prices than consumers, and can therefore implement price discrimination strategies in setting service prices. Due to the disadvantage in acquired information, consumers on average need to pay a price 4.86% higher than a reasonable transaction price. In addition, the information asymmetry problem in urban areas is relatively more serious than in other areas. In terms of comparisons between cities, Hangzhou had the largest net surplus in the housing transaction market, followed by Jinhua, Ningbo, and Wenzhou.

Keywords: Housing price, Information asymmetry, A two-tier frontier model, China

1. Introduction

The problem of unaffordable housing in China has become an economic, social, and political issue. With the presence of rapid changes in the Chinese economy, the real estate industry in China has undergone remarkable development, whereas the problem of market differentiation also grow. More specifically, there is an imbalance in the supply and demand in the housing market, and the housing prices have continued to rise in major cities, which leads to a growing risk of price bubbles. Meanwhile, the formation of a poverty-stricken neighborhood, and the phenomenon of insured citizens giving up lending or purchasing affordable housing, have led to the creation of a sandwich layer. Less developed cities are facing a series of conflicts and dilemmas related to housing, such as high inventory pressure and insufficient demand for housing consumption. How to effectively carry out a reform to simultaneously promote renting and purchasing in the housing market and enable every citizen an affordable house has become an urgent problem of people's livelihood. In this situation, the Chinese government has insisted on conducting regulation and control in the real estate market, and has continued to expand its scope and strength. In 2017, more than 60 cities across China have successively launched purchase restriction policies. In 2018, as many as 438 restrictive policies such as purchase restriction, loan restriction, price restriction, and sales restriction were issued. In order to curb speculation in the real estate market, in 2019, various provincial capitals and major cities joined the team to regulate housing prices to a better stage. They enacted updated versions of the purchase restriction policies and

prevented house prices from rising irrationally by restricting enterprises in buying houses. However, even though the government has successively adopted measures such as purchase-limit, price-limit, sale-restriction, and de-stocking to guide investment in the real estate market and therefore slow down the growth rate of house prices, the overall house prices still remain high.

There are various factors that may affect the differentiation of housing prices. In addition to macro-level influences such as the political, economic, social effects (e.g., governmental policies, economic prosperity, population growth), one of the key factors affecting the differentiation of housing prices is the liquidity of information in the market transaction. According to economic theory, due to high transaction costs and low liquidity of housing transaction, consumers often faces different information searching costing when they tend to buy or rent houses, which leads to the phenomenon known as 'price dispersion'. Related research further argues that differentiation in housing price is affected by price dispersion, and price dispersion is closely related to the low liquidity of information in the market transaction. However, after reviewing previous studies about the housing industry in China, it can be found that few empirical studies have focused on information about the market transaction.

In reality, buyers and sellers in the real estate market often have different expectations about housing prices. The running of the whole market reflects the degree of competition; when different transaction prices appear among homogeneous goods, there is information asymmetry between the buyer and the seller. *Search theory* assumes that: without price discrimination, the difference in commodity quality will be reflected in the price level; that is, products with similar qualities should have the same price level (Phlips, 1983; Wang et al., 2021). In search of a specific product, consumers will not pay for the products if the price is higher than the maximum price they are willing to pay (Chen & Zhang, 2021). On the contrary, if the price is lower than or equal to the price they are willing to pay, the consumer would tend to consume. Similarly, the producers would not produce products if the selling price is lower than their minimum acceptable price, and they will only produce when the commodity price is higher than or equal to the minimum acceptable price. With sufficient market information, that is, when every consumer knows the lowest acceptable price of the producer, the consumers will inevitably choose to buy from the seller who provides the same goods with the lowest price. Similarly, when the sellers know the maximum price that consumers are willing to pay, they will sell the products at the highest price. These only happen when both the buyer and the seller have sufficient information. However, if the market information is not sufficient enough, consumers can not have complete information about the seller in the market; the sellers will also lack clear information about the highest price that the buyer is willing to pay. This would lead to price differences. More specifically, insufficient information may lead to the situation that products with the same quality have different price levels, or that products with the same price level have different levels of quality.

Taking **Fig. 1** as an example, it is assumed that in a fully competitive housing market with sufficient information for both the buyer and the seller, the horizontal axis is the amount of supply in the housing market, and the vertical axis is the price level of houses. Given sufficient information, the sellers know the maximum potential price P_{max}^{buyer} that the buyer is willing to pay (i.e. the actual demand price of the consumer), and the buyers can also know the minimum potential price P_{min}^{seller} that the seller is willing to accept (i.e. the retention price of the builder). In this case, the equilibrium house price of houses with the same quality in the housing market should be $P = P^*$. Now we can come to the reality, where there is information opacity.

That is to say, information is insufficient and asymmetric between buyers and sellers in the real estate market. As a result of insufficient information, there are different price combinations when the buyers and sellers try to sign a contract and decide the transaction price. In a large sample, the distribution of the overall house price follows a normal distribution. The highest price that consumers are willing to pay and the lowest acceptable price of suppliers are P_{max}^{buyer} and P_{min}^{seller}, respectively. Suppose that the observed house price is P_0. In the case of sufficient information, the seller should be able to negotiate with the buyer and get the transaction price of P_{max}^{buyer}. However, due to insufficient information, the sellers do not know the highest price the consumers are willing to pay, and therefore only get the price P_0 in the transaction process. This kind of transaction difference ($P_{max}^{seller} - P_0$) caused by incomplete information, is called 'information ignorance' in previous literature (Pan et al., 2019).

Similarly, suppose that the observed house price that the seller and the buyer in the housing market decide is P_1. With sufficient

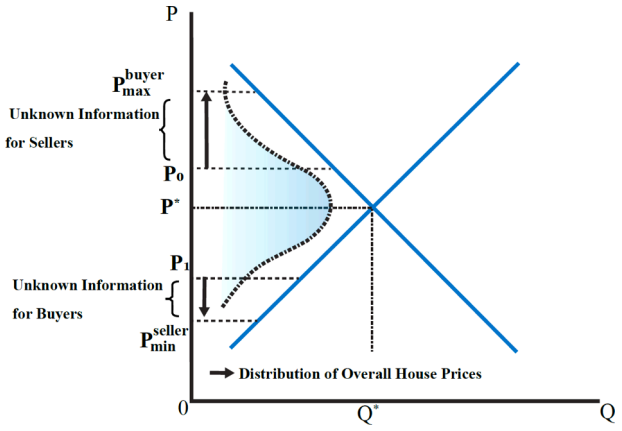

Fig. 1. Information ignorance for Buyers and Sellers.

information, buyers will notice that the minimum acceptable house price for sellers is P_{min}^{seller}. However, in reality, the buyer cannot know P_{min}^{seller}. They can only estimate the value of the house or guess the ideal house price of the sellers (i.e. the retention price) based on several information (such as house age, floor area, nearby traffic convenience, building material composition, and house structure). If the supplier's minimum acceptable house price $P_{min}^{seller}$is lower than the price provided by the consumer (P_1), there will be a difference score of P_1-P_{min}^{seller}. Such a difference is also a kind of information ignorance. Considering the above problems, there would be different levels of house prices in the market, resulting in house price dispersion. The distribution of house prices is affected by the degree of information ignorance from the buyer or the seller. Therefore, estimating the degree of information ignorance or information transparency can help further clarify the problem of price dispersion.

The degree of information sufficiency in the market reflects whether the operation of the commodity market is efficient. When both the buyer and the seller in the commodity market can get sufficient information about each others' characteristics, nature, highest willingness to pay, and the lowest acceptable bid level, the trading operation of the commodity market can work efficiently. In this case, the degree of imbalance in consumer and producer surplus can also be reduced. Through the market operation, both sides of the transaction can eventually reach equilibrium during the transaction process. Conversely, if the market cannot function as described above, what would happen to the adequacy of information in the market? This is the subject to be explored in this study. Different from previous study focus on macro-level, this study selects the two-tier stochastic frontier model and includes micro-level data, to analyze the real estate transaction data in the city and differences in price information acquired by the buyers and the sellers. Different from most of the existing literature that discusses the trend of overall housing prices, the empirical results found in this study emphasize the changes in information differences between consumers and suppliers.

Based on the micro-level data of new house transactions in Hangzhou, Wenzhou, Ningbo, and Jinhua of Zhejiang Province, this paper applies the two-tier frontier model to estimate the degree of information asymmetry between buyers and sellers in the real estate transaction and analyzes the impact of this asymmetric information on the transaction price. The main structure of this paper is as follows: the first section is the introduction, and the second section reviews related works of literature; the third section introduces the research methods, and the fourth section explains the data sources and studied variables; the fifth section presents the empirical analysis, describes the empirical results and economic significance; the last section is the conclusion of this paper.

2. Literature Review

Previous studies have long been investigating the price dispersion between commodities, labors, and environment, and have been conducting empirical analysis in various industries (Pan, et al., 2019; Yang et al., 2019). For example, Stigler (1961) analyzed the price dispersion of Chicago automobile industry and coal market in the United States; Pratt et al. (1979), Carlson and Pescadrice (1980) compared the price differences of various commodities in the market; Gaynor and Polachek (1994) explored the price differences of traditional Chinese medicines in the medical market in the United States and the differences in the information held by doctors and patients; Hofler and Murphy (1992), Polachek and Yoon (1987,1996), Murphy and Strobl (2008) studied the wage differences among employees in the labor market; Reed (1991), Zorn and Sackley (1991), Hsu (2011) discussed the price dispersion and dispersion degree of the housing market. Some of the abovementioned studies suggested that the dispersion of commodity prices was related to the searching cost of consumers and the production cost of producers. For example, Carlson and McAfee (1983) pointed out thatthe dispersion degree of equilibrium price of consumers with searching behaviors would be smaller than that of customers without such behaviors; if the searching cost of consumers or the production cost of producers increases, the dispersion degree of price might also increase. It has also been emphasized that the transparency of market information is generally negatively related to the price dispersion of commodities. When the degree of market information incompleteness increases, the fluctuation and dispersion of commodity prices usually also increase (Pei, 2019). Just like labor studies of Polachek and Yoon (1987), scholars such as Lawrence et al. (2021), Bergers (2022) and Landry (2022) continuely pointed out that similar products often faces differences in the price; products with different capital accumulation also might tagged similar prices. The main reason behind this phenomenon is related to the insufficient market information owned by both the labor and the capital in the market.

In terms of studies focusing on real estate price dispersion, Reed (1991) pointed out that due to a high transaction cost and low liquidity of products in the housing market, the price dispersion often appears in a way that consumers have different searching costs for houses. Chiang et al. (2019) used data of the housing market in Taiwan from 2012 to 2017 to compare the differences between the fixed price settled by the sellers and the actual transaction price, and found that the price dispersion of the actual transaction price was lower than the price dispersion of fixed price, both in the market of rental, completed houses, resold houses and self-built houses. It showed that the distribution or the fluctuation of house prices became smaller in the process of transaction, as consumers searched for related information about the houses. Salvati et al. (2019) studied the impact of the overall economy on the dispersion of housing prices. They argued that as both the supplier and consumer were inexperienced market participants in the market of resold houses, the phenomenon of price dispersion continued to exist in the housing market. In addition, the empirical results verified the conclusion Leung et al. (2006) proposed that the overall economy had both a concurrent and a longitudinal impact on housing price volatility.

With regard to other related studies, for example, Bayer et al. (2017) analyzed the housing market and land price of ethnic minorities and low-income residential areas in the United States and found that in residential areas, the housing market suppliers had price discrimination against specific ethnic groups. The authors believed that part of the reasons was related to the characteristics of human capital and the income of the consumers; poverty and low income may increase the degree of insufficient information acquired by the consumers, resulting in price discrimination. The special characteristics of housing commodities may increase the degree of information asymmetry between suppliers and consumers in the housing market. As both the suppliers and consumers cannot get

information about the expected price ofeach other, they would both have transaction information costs. However, after reviewing previous literature on housing prices, we found that in addition to Zhang et al. (2017) and Lin and Jiang (2019), there were only a few studies that used the microdata of the housing market to analyze the principal-agent and information asymmetry in market transactions. In addition, in recent years, with the popularity of the Internet and the development of the real estate intermediary industry, the housing market has attracted numerous competitors. However, the lack of a relevant legal supervision system has led to various problems in the industry. The problem between the buyer and the seller and the real estate agency caused by asymmetric information is a typical principal-agent problem, in which both the buyer and the seller are the principal, while the real-estate agency is a typical agent. Without the intervening of the real-estate intermediary, the seller tend to have a greater information advantage over the buyer, as the seller often has more information about the houses listed for sale (De Long et al, 1990; Zhang et al., 2017). However, when the real-estate intermediary is involved, direct communication between the buyer and seller is prevented as the real-estate intermediary works as a necessary medium to exchange information. In this case, supervision of the agent is usually too costly for both the seller and the buyer, so that they are situated in a disadvantaged position for obtaining sufficient information. Kumbhakar and Parmeter (2009) regard the transaction loss caused by the information disadvantage of the supplier and the consumer as an information tax and use the bilateral stochastic frontier model to conduct quantitative analysis. Zhang et al. (2017) further pointed out that after the housing seller employed an intermediary agency to sell the houses, it often failed to obtain a reasonable price it deserved. Due to information disadvantage, housing buyers often need to purchase the desired housing at a price higher than the reasonable market price.

Based on the literature review, it can be seen that few studies discussed the issue of price dispersion in the housing market of China. Furthermore, most of the existing research on real estate focuses on time series analysis such as the macroeconomic environment and the fluctuation of the average house price in different countries or cities (Gross and Lin, 2020; Wang et al., 2020). However, these literature has been criticized for failing to explain the causal effects inside the market (Chen and Tongurai, 2021; Repasky, 2021; Nguyen et al., 2020; Lee et al., 2021). For example, Grout (2021) points out that deep mining in micro-market data is necessary to explain financial markets changes such as housing markets and their micro-drivers such as information symmetry. In this paper, we therefore use a two-tier frontier model to analyze the information adequacy of the housing market in four developed cities with active transactions of Zhejiang Province: Hangzhou, Wenzhou, Ningbo, and Jinhua (Chang, Chou, & Hu, 2017; Zhang, Chou, & Chen, 2022). In addition, different from previous studies that collect transaction data from paperwork and books, we adopted a data retrieval process that takes advantage of the development of network resources. More specifically, data were collected with the help of big data and an online atlas (Tsai and Dai, 2020; Albarrak et al., 2020; Bai, Chou, & Zhang, 2021). Our approach is therefore consistent with the integration of AI and big data technologies advocated by Grout (2021) to bridge the long-term interdisciplinary barrier between micro and macro. In addition, in terms of the influences of information asymmetry, it also affect a series of factors such as the regulation (Ambrose and Diop, 2021), supply chain (Malmir and Zobel, 2021), policy effectiveness (Behmanesh et al., 2013; Yang et al., 2021), social choice (Bahrini et al., 2021), operating strategy (Malmir and Spicar, 2014; Esmaeili et al., 2015; Mohamadi and Bahrini, 2020), and risk assessment (Jahantigh et al., 2017). Our approach attempt to estimate and evaluate the degree of information asymmetry and the bargaining difference between sellers and buyers.

3. Methodology

The estimating approach is illustrated in **Fig. 2**. Based on the purpose of pursuing utility maximization, the buyers tend to lower the housing price. Therefore, the expected price of consumers locates below the frontier line. On the contrary, sellers aim for profit maximization, and thus the expected housing price of suppliers locates above the frontier line. A greater influence of the bargaining power of the buyers or the sellers on the final transaction is associated with a smaller deviation between the frontier line and the expected housing price level. The basic idea of the two-tier stochastic frontier model is to adjust the degree of deviation and measure the bargaining power of both parties.

Based on previous studies (Polachek and Yoon, 1987, 1996; Gaynor and Polachek, 1994; Kumbhakar and Parmeter, 2009; Lu et al., 2011; Zhang et al., 2017; Lin and Jiang, 2019; Zhao et al., 2019), it can be assumed that in a typical housing transaction market, there

Fig. 2. The concept of a two-tier stochastic frontier model.

are numerous housing suppliers and consumers, and both of them have certain tendency to bargain. Therefore, the final price of the houses (P) can be calculated as follows:

$$P = \underline{P} + \eta\left(\overline{P} - \underline{P}\right) \tag{1}$$

Among which, $\underline{P}$ is the lowest price that can be accepted by the seller and $\overline{P}$ is the highest price that the buyer is willing to pay. η is an estimation of the bargaining ability in the process of deciding the price, ranging from zero to one. Therefore, $\eta\left(\overline{P} - \underline{P}\right)$ reflects the surplus from the profit made by the seller in the process of deciding the house prices.

In order to simultaneously reflect the degree of information that buyers and sellers hold in the process of deciding house prices, we expand the equation (1). First, given individual characteristics x, a fair house price can be expressed as $\mu(x) = E(\theta|x)$, where θ refers to the actual presence, and $\underline{P} \le \mu(x) \le \overline{P}$. However, factors are unknown. Therefore, $\overline{P} - \mu(x)$ refers to the consumer surplus that buyers get from getting price information in housing transaction;$\mu(x) - \underline{P}$ refers to the producer surplus. Whether the buyer or the seller gets a higher surplus depends on the bargain ability and information they have (Osbourne & Rubinstein,1990). Therefore, Equation (1) can be expanded as:

$$\begin{aligned} P &= \mu(x) + \left[\underline{P} - \mu(x)\right] + \eta[\overline{P} - \mu(x)] - \eta\left[\underline{P} - \mu(x)\right] \\ &= \mu(x) + \eta[\overline{P} - \mu(x)] - (1-\eta)\left[\mu(x) - \underline{P}\right] \end{aligned} \tag{2}$$

As it is shown in Equation (2), the seller can raise the deal price in housing transaction by depriving parts of the expected surplus of the buyer, and the scale of the deprived surplus is $\eta[\overline{P} - \mu(x)]$. Similarly, the buyer can reduce the deal price of the house by depriving parts of the expected surplus of the seller, and the scale of the deprived surplus is $(1-\eta)\left[\mu(x) - \underline{P}\right]$. The degree of surplus that the seller can deprive depends on the amount of information they have (η) and the total number of the expected surplus of the buyer, denoted by $\overline{P} - \mu(x)$. Therefore, the seller can raise the deal price given the information they have. Similarly, the degree of surplus that buyers can get depends on the information they have $(1-\eta)$ and the total expected surplus of the seller, denoted by $\mu(x) - \underline{P}$. Buyers can reduce the deal price with the information they have.

Based on the above discussion, the two-tier frontier model predicting the sold house price can be set as:

$$P_i = \mu(x) + \varepsilon_i, \varepsilon_i = w_i - u_i + v_i \tag{3}$$

Among which, $\mu(x) = x_i^{'}\beta$, where β is a parameter vector to be estimated, and x_i is the individual characteristics of the sample; $w_i = \eta_i[\overline{P}_i - \mu(x_i)] \ge 0; u_i = (1-\eta_i)\left[\mu(x_i) - \underline{P}_i\right] \ge 0;$

v_i is a random error term in a general sense. w_i represents the scale of surplus that the sellers deprive with the information they have and u_i represents the surplus the buyers deprive through gathering information. Net surplus ($NS = \eta[\overline{P} - \mu(x)] - (1-\eta)\left[\mu(x) - \underline{P}\right]$) can be used to describe the overall effect of information asymmetry on housing prices in the process of the housing transaction. In order to simultaneously estimate the parameter β and the surpluses that buyers and sellers deprive with the information they have, Maximum Likelihood Estimation (MLE) was applied to estimate Equation (3). It is assumed that w_i and u_i follow an exponential distribution, $w_i \sim i.i.d.\ Exp(\sigma_w, \sigma_w^2), u_i \sim i.i.d.\ Exp(\sigma_u, \sigma_u^2)$. v_i follows a normal distribution, $v_i \sim i.i.d.\ N(0, \sigma_v^2)$. w_i, u_i and v_i are mutually independent. Based on the above assumptions, the probability density function to calculate the compound error term can be developed as:

$$\begin{aligned} f(\varepsilon_i) &= [\sigma_w + \sigma_u]^{-1}\left[\exp(a_i)\Phi(c_i) + \exp(b_i)\int_{-h}^{\infty}\phi(z)d(z)\right] \\ &= [\sigma_w + \sigma_u]^{-1}[\exp(a_i)\Phi(c_i) + \exp(b_i)\phi(h_i)] \end{aligned} \tag{4}$$

Where $\Phi(c_i)$ and $\phi(h_i)$ are probability density function and cumulative distribution function of the standard normal distribution respectively. Other parameters are set as follows:

$$a_i = \sigma_u^{-1}\left[\varepsilon_i + \sigma_v^2(2\sigma_u)^{-1}\right]; \mathrm{b_i} = \sigma_w^{-1}\left(-\varepsilon_i + \sigma_v^2(2\sigma_w)^{-1}\right);$$
$$\mathrm{h_i} = \varepsilon_i\sigma_v^{-1} - \sigma_v\sigma_w^{-1}; \mathrm{c_i} = -\varepsilon_i\sigma_v^{-1} - \sigma_v\sigma_u^{-1}$$

For a sample including n observations, the log-likelihood function can be expressed as follows:

$$\ln L(X;\ \theta) = -n\ln(\sigma_w + \sigma_u) + \sum_1^n \ln\left[e^{a_i}\Phi(c_i) + e^{b_i}\Phi(h_i)\right] \tag{5}$$

where $\theta = [\beta, \sigma_v, \sigma_u, \sigma_w]^{'}$. By seeking the maximization of the log-likelihood function, maximum likelihood estimates for all parameters can be obtained. The conditional distribution of u_i and w_i are $f(u_i|\varepsilon_i)$,$f(w_i|\varepsilon_i)$;

$$f(u_i|\varepsilon_i) = \lambda\exp(-\lambda u_i)\Phi(u_i/\sigma_v + h_i)[\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)]^{-1} \tag{6a}$$

$$f(u_i|\varepsilon_i) = \lambda\exp(-\lambda w_i)\Phi(w_i/\sigma_v + c_i)\exp(b_i - a_i)\{\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)\}^{-1} \tag{6b}$$

Where $\lambda = 1/\sigma_u + 1/\sigma_w$. Based on the conditional distribution determined in Equation (6), the conditional expectations of u_i and w_i in the process of deciding the housing price can be estimated as:

$$E(u_i|\varepsilon_i) = \lambda^{-1} + \exp(a_i - b_i)\sigma_v[\phi(-c_i) + c_i\Phi(c_i)][\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)]^{-1} \tag{7a}$$

$$E(w_i|\varepsilon_i) = \lambda^{-1} + \sigma_v[\phi(-h_i) + h_i\Phi(h_i)][\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)]^{-1} \tag{7b}$$

Furthermore, the net surplus (NS) from the bargaining process can be calculated as:

$$NS = E(1 - e^{-w_i}|\varepsilon_i) - E(1 - e^{-u_i}|\varepsilon_i) = E(e^{-u_i} - e^{-w_i}|\varepsilon_i) \tag{8}$$

As the parameter σ_u only appears in a_i and c_i, while σ_w only appears in b_i and h_i, they are both identified. Therefore, in subsequent model testing, it is not necessary to assume the relative size of the bargaining ability of the buyers and the sellers in advance. Instead, the bargaining ability is totally determined by the results of model estimation. This is also the fundamental advantage of the two-tier frontier model, and why it outperforms traditional regression analysis.

4. Data and Empirical Results

Different from previous studies that collect transaction data from published datasets (Bayer et al., 2017), we adopted a data retrieval process that takes advantage of the development of network resources. More specifically, data were collected with the help of Python and an online geographic platform (Tsai and Dai, 2020; Albarrak et al., 2020). This approach is inspired by various timely research promoted by the current rise of big data. Just like Grout (2021) advocated, integrating AI and big data techniques is the potential way to bridge the long-term interdisciplinary barrier between micro and macro. Specifically, our data retrieval uses Python as a tool to crawl transaction information such as housing price from Liangjiafang.com, the largest real estate transaction website in China, and to retrieve property information such as architectural characteristics online through Gode Map (similar to Google Map), a popular geographic platform in China.

In order to match with the published macro data, we adopted the real estate transaction data of 2018 (Zhang et al., 2017). Therefore, the present study includes 2018 data about newly-built house transactions from Lianjiafang.com in four cities: Hangzhou, Wenzhou, Ningbo and Jinhua. Data from the China Index Database and Statistical Yearbooks of several cities are also included and summarized as suggested by Chen et al. (2018). After checking missing values and outliers, a sample of 925 cases were included in the data analysis. In the present study, the dependent variable is the transaction price (Price), that is, the price that the buyers and sellers finally agree on after bargaining. The explanatory variables include the age of the house (Age), whether it is a rough house (House), population density (Density), whether it is located in an urban area (City), the current housing investment amount in the city (Invest), and the housing area in the city (Area). Descriptive statistics of related variables are summarized in **Table 1**.

4.1. Model Specification and factors affecting baseline prices

Based on the measurement model estimating bargaining ability in the housing trading market and the abovementioned methods, we analyzed the effect of the bargaining ability of buyers and sellers in deciding the house prices. The two-tier frontier method was used in the estimation, and **Table 2** shows the regression results using this method. As it is shown in **Table 3**, Model 1 used OLS estimation. Models 2-4 used MLE estimation with a two-tier frontier method. At the same time, constraints were added in Model 2, and the estimation results were similar to those with least square estimation. In Model 3 and 4, the model fit was significantly improved by adding factors such as housing investment and the average housing area of newly-built houses. Given that the empirical results were consistent across different models, the subsequent analysis was mainly conducted based on the results and variables included in Model 4. The empirical results of Model 4 showed that the age of the house (Age), whether it is a rough house (House), the housing investment (log (Invest)), and the average housing area of a newly-built house (log (Area)) had statistically significant effects on house prices. More specifically, sellers tended to accept a lower deal price in the transaction process when the house was older, was a rough house, and when the average housing area of a newly-built house was larger. As housing investment reflects the cost of the sellers in building the houses, higher values of housing investment would lead to rises in the deal prices that the sellers accept.

Table 1
Descriptive Statistics.

Variable	Definition	Mean	SD
Price	Price per square meter of the house (unit: RMB)	26,316	77,853
Age	Age of the house (unit: year)	2.860	2.860
House	Dummy, 1= rough house 0= others	0.581	0.494
Density	Population density	1588	2314
City	Dummy, 1= urban, 0= others	0.559	0.497
Invest	The housing investment amount in the current year of the city where the house locates (unit: 100 million yuan)	640.172	649.198
Area	The housing area in the current year of the city where the house locates (unit: square meters)	2.093	2.191

Table 2
Results of Regression Analysis in Predicting Housing Prices.

log(Price)	(1)OLS	(2)MLE 1	(3)MLE 2	(4)MLE 3
Age	−0.041**	−0.019***	−0.042**	−0.042**
	(0.019)	(0.017)	(0.016)	(0.016)
Age square	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
House	−0.148***	–0.165***	−0.140***	−0.136***
	(0.041)	(0.034)	(0.033)	(0.033)
Density	−3.98E-05***	−3.67E05***	1.72E-05*	1.48E-05
	(9.46E-06)	(7.95E-06)	1.04E-05	(1.08E-05)
City	0.560***	0.596***	0.628***	0.019
	(0.045)	(0.036)	(0.035)	(0.164)
log(Invest)			−0.234***	0.381**
			(0.038)	(0.168)
log(Area)			0.276***	−0.421**
			(0.037)	(0.186)
Region control	No	No	No	Yes
Constant	-0.718***	9.653***	8.618***	11.412***
	(0.050)	(0.050)	(0.176)	(0.723)
R square	0.256			
Log likelihood		−611.606	−578.120	−569.488
Sample	925	925	925	925

Notes: Standard Errors are reported in parentheses.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 3
The Effects of the Bargaining Ability on House Prices.

Definition	Variable	MLE 1	MLE 2	MLE 3
Random error	σ_v	0.260	0.251	0.239
The Bargaining Ability of the Consumers	σ_u	0.248	0.229	0.232
The Bargaining Ability of the Suppliers	σ_w	0.318	0.316	0.318
Total variance of random terms	$\sigma_v^2 + \sigma_u^2 + \sigma_w^2$	0.230	0.215	0.212
Variance Explained by Bargaining Ability	$(\sigma_u^2 + \sigma_w^2)/(\sigma_v^2 + \sigma_u^2 + \sigma_w^2)$	0.707	0.706	0.731
Variance explained by consumers' bargaining ability	$\sigma_u^2/(\sigma_u^2 + \sigma_w^2)$	0.377	0.344	0.349
Variance explained by suppliers' bargaining ability	$\sigma_w^2/(\sigma_u^2 + \sigma_w^2)$	0.623	0.656	0.651

4.2. Partitioning Variances: effect size of the bargaining model

Table 3 summarizes the results of the effect sizes of the bargaining ability. It can be seen that bargaining ability had a considerable impact on deciding the market price of houses. Estimation showed that the bargaining ability of the housing suppliers had a moderate and positive impact (σ_w=0.318) on increasing housing prices; the bargaining ability of the buyers had a moderate effect on reducing the house prices (σ_u= 0.248). Overall, the bargaining ability had a positive effect on house prices, and $E(w-u) = \sigma_w - \sigma_u = 0.070$, which indicates that bargaining, in general, would lead to a house price higher than the baseline price. At the same time, the

Table 4
Surpluses that consumers and suppliers get in the bargaining process (based on the estimation of MLE3).

Category	Mean(%)	SD(%)	Q1(%)	Q2(%)	Q3(%)
Total sample					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	23.74	12.9	14.34	19.39	28.28
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	18.88	9.43	12.72	15.22	21.27
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−4.86	19.76	−1.62	−4.17	−7.01
Urban					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	24.03	14.07	14.42	18.97	27.66
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	18.49	8.46	12.81	15.47	21.06
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−5.54	19.96	−1.61	−3.5	−6.6
Suburban					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	23.53	11.99	14.25	19.65	28.59
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	19.17	10.07	12.68	15.08	21.51
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−4.36	19.62	−1.57	−4.57	−7.08

unexplained variance of log (Price) out of the total variance ($\sigma_v^2 + \sigma_u^2 + \sigma_w^2$) was 0.230, and 70.7% of the total variance was explained by bargaining ability, which represents the percentage of total variance explained by the bargaining ability ($\sigma_u^2 + \sigma_w^2)/(\sigma_v^2 + \sigma_u^2 + \sigma_w^2$). Looking into the explained variance, it can be seen that the bargaining ability of the suppliers played a decisive role in deciding the house prices, as 62.3% of the total explained variance were due to the bargaining ability of the suppliers (namely $\sigma_w^2/(\sigma_u^2 + \sigma_w^2)$ in Table 3). The bargaining ability of the consumers accounted for only 37.7% of explained variance (namely $\sigma_u^2/(\sigma_u^2 + \sigma_w^2)$ in Table 3). In order to further analyze the 'supplier-consumer' surpluses respectively and the net surpluses in the bargaining process, we further estimated the unilateral effects of the buyers and sellers on deciding the house prices.

4.3. *Estimation of Consumer Surplus and Supplier Surplus*

Base on equation (8), weestimatedthe bargainingabilityof buyers and sellers of housesin Table 4, namely $E(u_i|\varepsilon_i)$ and $E(w_i|\varepsilon_i)$. It is the percentage of the surpluses obtained by consumers and suppliers in the negotiation for the change in the baseline price. Table 4 presents the results of the estimation including the whole sample. On average, the surplus obtained by the housing supplier in bargaining was 23.73% higher than the baseline price of the commercial housing, while consumer surplus can only reduce the price of commercial housing by 18.88%. This discrepancy in bargaining ability made the actual house price 4.86% higher than the baseline price. In other words, due to the information asymmetry between buyers and sellers and the difference in bargaining ability, consumers needed to pay 104.86 yuan for a house worth 100 yuan in a fair market.

The last three columns (Q1-Q3) in Table 4 present the distribution of the surpluses of the buyers and sellers of the house in detail, indicating that the differences in the bargaining ability of the house buyers and sellers are highly heterogeneous. This result indicates that not all consumers were in a disadvantaged situation. More specifically, according to the results of the first quartile (Q1), it can be seen that for a quarter of the consumers, the housing suppliers can only obtain a net surplus of no more than 1.62%. However, results from the third quartile (Q3) show that, for another quarter of the consumers, the suppliers deprived a surplus higher than 7.01%.

In terms of whether the houses are located in urban areas, suppliers in urban areas had a stronger bargaining ability than suppliers in other areas. However, the net surplus of customers' bargaining ability is slightly higher in non-urban areas than that in urban areas. All consumers are faced with accepting an equilibrium price that was 4.36% higher than the baseline price. At the same time, consumers in different quartiles face different increases in price.

Fig. 3-5 more intuitively shows the distribution of the surpluses of both the housing suppliers and consumers, as well as the net surplus of both side. As can be seen from Fig. 3 and Fig. 4, for both the suppliers and consumers, the distribution was tailed to the right, indicating that only a few suppliers or consumers had an absolute bargaining ability. From the distribution of net surplus in Fig. 5, it can be seen that not all consumers were in a disadvantaged position in the process of housing price negotiation. Overall, it is believed that in the bargaining process, the house suppliers had bargaining abilities considerably higher than the consumers, and they made use of this ability to implement a price discrimination strategy in the process of setting house prices.

Finally, Table 5 summarizes the distributions of housing transaction information between buyers and sellers in each city. In terms of regional differences, the data showed that among the four cities, the final net surplus (degree of information asymmetry) in the commercial housing transaction was the highest in Wenzhou. The bargaining ability of the house suppliers in Wenzhou was the highest among suppliers in the four cities, while at the same time consumers in Wenzhou also had the highest bargaining ability among consumers in the four cities. However, overall, the net surplus of the Wenzhou market was the lowest among the four cities (-5.23%), while Hangzhou obtained the largest net surplus (-4.29%). A plausible reason may be that the strong government supervision in Hangzhou, the capital of the province, ensured a high degree of openness and transparency of housing information. As a result the consumer's right to receive enough information is protected. Therefore, the housing market needs proper supervision from the governments to increase the fairness and openness. This approach would help to increase the effective information exchange on commercial housing and improve the bargaining ability of consumers, so as to effectively control the continuous rise of commercial

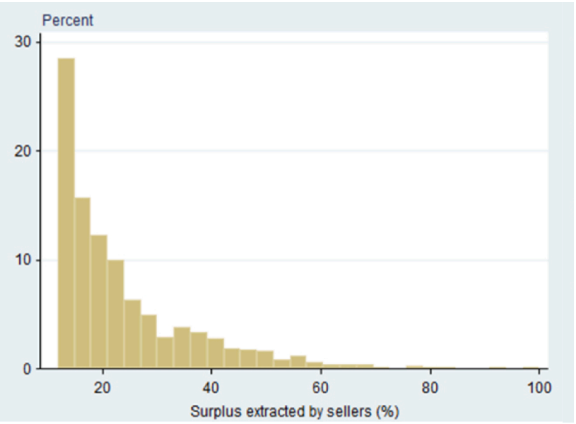

Fig. 3. Distribution of Surplus gained by suppliers.

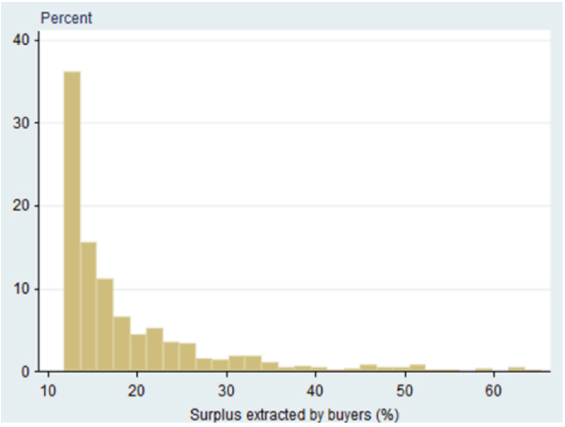

Fig. 4. Distribution of Surplus gained by consumers.

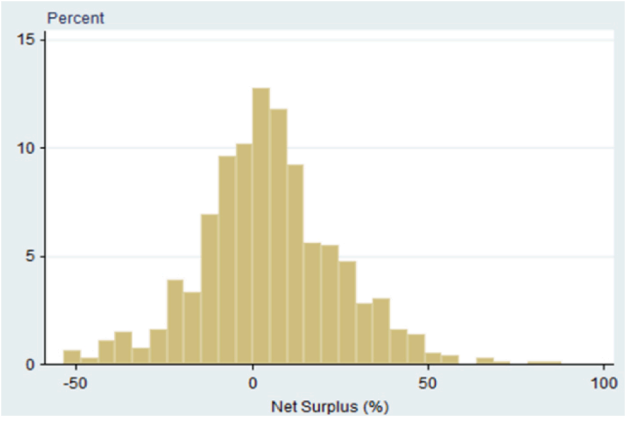

Fig. 5. Distribution of Net Surplus.

Table 5
Supplier Surplus, Consumer Surplus and Net Surpluses in Four Cities (Based on the estimation of MLE3).

Region	Mean(%)	SD(%)	Q1(%)	Q2(%)	Q3(%)
Wenzhou					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	24.62	14.21	14.29	19.23	29.67
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	19.39	10.62	12.56	15.31	21.39
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−5.23	21.85	−1.73	−3.92	−8.28
Hangzhou					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	22.73	11.01	14.37	19.83	25.66
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	18.44	8.45	13.13	14.99	21.2
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−4.29	17.39	−1.24	−4.84	−4.46
Ningbo					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	23.64	13.04	14.21	19.35	28.59
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	18.66	8.66	12.68	15.24	21.61
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−4.98	19.34	−1.53	−4.11	−6.98
Jinhua					
Supplier $\widehat{E}(1-e^{-w}\|\varepsilon)$	22.7	10.46	15.35	18.37	27.66
Consumer $\widehat{E}(1-e^{-u}\|\varepsilon)$	18.25	7.64	12.81	15.87	19.17
Net surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−4.45	16.59	−2.54	−2.5	−8.49

housing prices.

5. Conclusion

As a limited number of previous studies has explored the issue of price dispersion in the real-estate market, the present study uses the method of a two-tier frontier model to analyze the effects of transaction information transparency on the fluctuation of housing prices in 2018 in four cities, that is, Hangzhou, Wenzhou, Ningbo, and Jinhua. Compared with other methods, a two-tier frontier model has the advantage of enabling the estimation of the price information mastered by individuals in the market by applyingthe method used to calculate manufacturers' technical efficiency in production performance. The results showed that the age of the house, whether it is a rough house, whether the house is located in the urban area, the scale of housing investment, the housing area of newly-built houses, and the regional population density had significant effects on the fluctuation of urban house prices. Secondly, the present study estimates the degree of information mastery about housing transactions in urban areas, suburb urbans, and across different cities. The results showed that the information asymmetry problem in the distribution of housing market transaction information was relatively larger in urban areas, with a net surplus of -5.54% compared with the net surplus in suburban areas (-4.36%). In terms of comparisons between cities, Hangzhou obtained the largest final net surplus (-4.29) in the housing market, followed by Jinhua (-4.45%), Ningbo (-4.98%), and Wenzhou (-5.23%). The empirical results showed that in the housing transaction process, the supplier had more complete information on real estate prices than consumers, and can rely on this discrepancy to implement price discrimination strategies in setting service prices.

Based on these findings, it can be concluded that there is information asymmetry in real estate transactions in China. In order to reduce the problem of information asymmetry, the Chinese real estate market may pilot an approach known as real-value login information to disclose real estate industry transaction information and guide the citizens to be rational and organized when considering buying houses. This might help the healthy development of the real estate market. Secondly, the development of the real estate market in China may be affected by the relatively simple investment channels. Therefore, new investment channels may be introduced to guide private investment, so that the rising real estate prices can be appropriately adjusted. The research results showed that fluctuations in housing price were related to the transparency of transaction information. The government is suggested to regulate the developmental speed of the property market in a timely manner, and strengthen the monitoring of land supply, housing supply information, and price trends. Guiding residents' expectations and appealing for rational house purchases may also benefit the benign development of the real estate market. In addition, the government can regulate the private lending market. On the one hand, publicity and education, can be used to makepeople fully aware of the harmfulness of usury and thus regulate private lending behaviors; on the other hand, effective policies can be formulated to guide private lending funds to the real economy, and give the supplementary function of private lending funds a full play of.

Some limitations of the present study and suggestions for future research are discussed. As the two-tier frontier method is used for data analysis, maximum likelihood estimation is used in model estimation. However, the initial value condition andsample size may lead failtures in model to convergence. Furthermore, the data cannot be prepared as panel data for analysis due to factors such as transaction period, the number of transactions, or data aggregation in the housing market. Thus, we cannot further discuss the fixed effects or random effects of study variables. In addition, this study empirically estimated the degree of value information mastery in the overall market. Future research may refer to Polachek and Yoon (1987, 1996), Lu et al. (2011), Zhang et al. (2017), and employ panel data to investigate the mastery of price information on both sides of intertemporal buying and selling.

CRediT authorship contribution statement

Ganlin Pu: Methodology, Formal analysis, Writing – original draft. **Ying Zhang:** Software, Validation. **Li-Chen Chou:** Conceptualization, Methodology, Validation, Writing – original draft, Supervision.

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References

Albarrak, M. S., Elnah, M., Papagiannid, S., & Sala, A. (2020). The effect of twitter dissemination on cost of equity: A big data approach. *International Journal of Information Management, 50*, 1–16.

Ambrose, B. W., & Diop, M. (2021). Information Asymmetry, Regulations and Equilibrium Outcomes: Theory and Evidence from the Housing Rental Market. *Real Estate Economics, 49*(S1), 74–110.

Bahrini, A., Riggs, R. J., & Esmaei, M. (2021). Social choice Rules, Fallback Bargaining, and Related games in common resource conflicts. *Journal of Hydrology, 602*, Article 126663.

Bai, Y., Chou, L., & Zhang, W. (2021). Industrial innovation characteristics and spatial differentiation of smart grid technology in China based on patent mining. *Journal of Energy Storage, 43*, 103289.

Bayer, P., Casey, M., Ferreira, F., & McMillan, R. (2017). Racial and ethnic price differentials in the housing market. *Journal of Urban Economics, 102*, 91–105.

Behmanesh, I., Madani, K., Geiger, C. D., & Bahri, A. (2013, October). Stability analysis of the proposed Caspian Sea governance methods. In *2013 IEEE International Conference on Systems, Man, and Cybernetics* (pp. 1777–1782). IEEE.

Bergers, D. (2022). The status quo bias and its individual differences from a price management perspective. *Journal of Retailing and Consumer Services, 64*, Article 102793.

Carlson, J. A., & Mcafee, R. P. (1983). Discrete Equilibrium Price Dispersion. *Journal of Political Economy, 91*, 480–493.
Carlson, J. A., & P.escatrice, D. R. (1980). Persistent Price Distribution. *Journal of Economics and Business, 33*, 21–27.
Chang, W., Chou, L., & Hu, B. (2017, September). Empirical Analysis of Real Estate Financial Risk in Wenzhou. In *International Conference on Transformations and Innovations in Management (ICTIM 2017)* (pp. 867–877). Atlantis Press.
Chen, C. Y., Li, S. H., Chou, L. C., & Chen, K. D. (2018). A Comparative Study of Production Efficiency in Coastal Region and Non-Coastal Region in Mainland China: An Empirical of Metafrontier Model. *The Journal of Trade and Economic Development, 27*, 901–916.
Chen, M., & Zhang, W. H. (2021). Purchase intention for hydrogen automobile among Chinese citizens: The influence of environmental concern and perceived social value. *International Journal of Hydrogen Energy, 46*(34), 18000–18010.
Chen, X., & Tongurai, J. (2021). The Relationship Between China's Real Estate Market and Industrial Metals Futures Market: Evidence from Non-price Measures of the Real Estate Market. *Asia-Pacific Financial Markets*, 1–35.
Chiang, Y., Ku, Y., Liu, F., & Chang, C. (2019). House price dispersion in Taipei residential communities. *International Real Estate Review, 22*, 109–129.
De Long, J. B., Shleifer, A., Summers, L. H., & Waldmann, J. (1990). Positive Feedback Investment Strategies and Destabilizing Rational Speculation. *The Journal of Finance, 45*, 379–395.
Esmaeili, M., Bahri, A., & Shayanrad, S. (2015). Using game theory approach to interpret stable policies for Iran's oil and gas common resources conflicts with Iraq and Qatar. *Journal of Industrial Engineering International, 11*(4), 543–554.
Gaynor, M., & Solomon, W. P. (1994). Measuring Information in the Market: An Application to Physician Services. *Southern Economics Journal, 60*, 815–831.
Gross, M., & Lin, C. (2020). Comparison of real estate management system in China and Poland. *Real Estate Management and Valuation, 28*(1), 13–27.
Grout, P. A. (2021). AI, ML, and competition dynamics in financial markets. *Oxford Review of Economic Policy, 37*(3), 618–635.
Hofler, R. A., & Mrphy, J. M. (1992). Underpaid and Overworked: Measuring the Effect of Imperfect Information on Wages. *Economic Inquiry, 30*, 511–529.
Hsu, S. Y., Yuan, S. M., & Chang, O. (2011). Price Dispersion of New Housing Projects: Analysis of Price Level, Timing and Location. *Journal of City and Planning, 38*(4), 403–426.
Jahantigh, F. F., Malmir, B., & Avilaq, A. (2017). Economic risk assessment of EPC projects using fuzzy TOPSIS approach. *International Journal of Industrial and Systems Engineering, 27*(2), 161–179.
Kumbhakar, S. C., & Parmeter, C. F. (2009). The Effect of Match Uncertainty and Bargaining on Labor Market Outcomes: Evidence from Firm and Worker Specific Estimates. *Journal of Productivity Analysis, 31*, 1–14.
Landry, P. (2022). Pricing, advertising, and endogenous consideration of an "insistent" product. *International Journal of Industrial Organization, 80*, Article 102798.
Lawrence, J. M., Scheer, L. K., Crecelius, A. T., & Lam, S. K. (2021). Salesperson Dual Agency in Price Negotiations. *Journal of Marketing, 85*(2), 89–109.
Lee, S. H., Kim, J. H., & Huh, J. H. (2021). Land Price Forecasting Research by Macro and Micro Factors and Real Estate Market Utilization Plan Research by Landscape Factors: Big Data Analysis Approach. *Symmetry, 13*(4), 616.
Leung, C., Leung, Y. C. F., & Wong, S. K. (2006). Housing Price Dispersion: An Empirical Investigation. *Journal of Real Estate Finance and Economics, 32*, 195–207.
Lin, L., & Jiang, M. (2019). Is the Transaction of Real Estate in China Really a Seller's Market? Empirical Study Based on Two-Tier Stochastic Frontier Model. *Journal of Audit and Economics, 34*(2), 105–115.
Lu, H., Lian, Y., & Lu, S. (2011). Measurement of the Information Asymmetric in Medical Service Market of China. *Economic Research Journal, 46*(4), 94–106.
Malmir, B., & Spicar, R. (2014). A system dynamics approach to housing prices: A case study of the Tehran real estate market. In *24th IBIMA conference*.
Malmir, B., & Zobel, C. W. (2021). An applied approach to multi-criteria humanitarian supply chain planning for pandemic response. *Journal of Humanitarian Logistics and Supply Chain Management*.
Mohamadi, M., & Bahrini, A. (2020). A Nash–Stackelberg equilibrium model for internet and network service providers in the demand market—A scenario-based approach. *Wireless Networks, 26*(1), 449–461.
Murphy, A., & Strobl, E. (2008). Employer and Employee Ignorance in Developing Countries: The Case of Trinidad and Tobago. *Review of Development Economics, 12*, 339–353.
Nguyen, M., Xuan, P., & Bui, T. (2020). Causal relationship between banking system development and real estate market. *Management Science Letters, 10*(1), 41–52.
Pan, X., Zhang, W., & Chou, L. C. (2019). The Theory on the Environmental Emission Trading Under the Concept of Two-Tired Earning. *Ekoloji, 28*, 1659–1663.
Pei, G. (2019). Uncertainty, Pessimism and Economic Fluctuations (No. 1494). Society for Economic Dynamics.
Phlips, L. (1983). *The economics of price discrimination*. Cambridge University Press.
Polachek, S. W., & Yoon, B. J. (1987). A Two-Tiered Earnings Frontier Estimation of Employer and Employee Information in the Labor Market. *The Review of Economics and Statistics, 69*, 296–302.
Polachek, S. W., & Yoon, B. J. (1996). Panel Estimates of a Two-Tiered Earnings Frontier. *Journal of Applied Econometrics, 11*, 169–178.
Pratt, J. W., Wise, D. A., & Zeckhauser, R. (1979). Price Differences in Almost Competitive Markets. *Quarterly Journal of Economics, 93*, 189–211.
Reed, C. (1991). Maintenance, Housing Quality, and Vacancies under Imperfect Information. *American Real Estate and Urban Economics Association Journal, 19*, 138–153.
Repasky, T. (2021). *Estimating causal effects by utilizing exogenous variation to limit the self-selection problem*.
Salvati, L., Ciommi, M. T., Serra, P., & Chelli, F. M. (2019). Exploring the spatial structure of housing prices under economic expansion and stagnation: The role of socio-demographic factors in metropolitan Rome, Italy. *Land use policy, 81*, 143–152.
Stigler, G. J. (1961). The Economic of Information. *Journal of Political Economy, 69*, 213–225.
Tsai, P. C., & Dai, S. H. (2020). Estimating the proportion of informed traders in BTC-USD market using spread and range. *Advanced studies of financial technologies and cryptocurrency markets* (pp. 197–210). Singapore: Springer.
Wang, S., Zeng, Y., Yao, J., & Zhang, H. (2020). Economic policy uncertainty, monetary policy, and housing price in China. *Journal of Applied Economics, 23*(1), 235–252.
Wang, W., Li, F., & Zhang, Y. (2021). Price Discount and Price Dispersion in Online Market: Do More Firms Still Lead to More Competition? *Journal of theoretical and applied electronic commerce research, 16*(2), 140–154.
Yang, L., Wing, C. W., & Chen, Y. (2021). Impacts of information asymmetry and policy shock on rental and vacancy dynamics in retail property markets. *Habitat International, 111*, Article 102359.
Yang, P. Y., Chou, L. C., & Wang, Z. A. (2019). Estimation of the Labor Market Information- An Empirical Study in Taiwan. *Journal of Intelligent and Fuzzy Systems, 37*(3), 3477–3487.
Zhang, Q., Su, G., & Liang, R. (2017). Who Affected the Second-Hand House Transcation Prices- Empirical Evidence from Beijing. *Finance and Trade Economics, 38*(2), 126–140.
Zhang, W. H., Chou, L. C., & Chen, M. (2022). Consumer perception and use intention for household distributed photovoltaic systems. *Sustainable Energy Technologies and Assessments, 51*, 101895.
Zhao, X. Z., Zhao, Y. B., Chou, L. C., & Leivang, B. H. (2019). Changes in Gender Wage Differentials in China: A Regression and Decomposition based on the data of CHIPS1995-2013. *Economic Research- Ekonomska Istraživanja, 32*(1), 3162–3182.
Zorn, T. S., & Sackley, W. H. (1991). Buyers' and Sellers' Markets: A Simple Rational Expectations Search Model of the Housing Market. *Journal of Real Estate Finance and Economics, 4*, 315–325.