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Pricing of Presale Contracts with Macroeconomic Factors and Stochastic Basis Risk

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ABSTRACT
This study analyzes the stochastic basis risk (presale price minus spot housing price) of presale housing from the viewpoint of forward pricing. We employ the modified Brownian bridge process to deal with the time-varying volatility and price convergence of presale and existing houses. The finding reveals an asymmetric effect of macroeconomic factors on the presale price in different market conditions. Such results might reflect the investors' behaviors of overreaction and/or over-pessimism. In addition, the influence of macroeconomic variables is greater on the basis price than on the prices of existing houses, especially in a depressed housing market. Our results emphasize the importance of considering basis risk and the influence of macroeconomic factors when pricing presale houses to manage housing risk.

KEYWORDS
Presale price; basis price; modified Brownian bridge process; macroeconomic factors

How to appropriately manage real estate risk has been a focus of government, industry, and academia, particularly after the subprime mortgage crisis. Financial markets take advantage of such timing and introduce many kinds of futures, options, and other derivative products linked to the housing price index as risk management tools of the real estate market. However, due to the significant heterogeneity of real estate, the hedging ability of the above-mentioned tools, which link to the overall housing price, is poor. Cao and Wei (2010) state that the non-tradability of housing indices renders the usual risk-neutral valuation technique powerless. In light of recent developments, this paper attempts to use the presale as a tool for managing housing risk. From the viewpoint of financial investments, presale housing can be regarded not only as forward/futures of new houses but also as having the heterogeneous characteristics of location; therefore, it is likely to provide proper risk management.

Presale housing refers to the sale of housing units before completion or even before construction has begun. From the viewpoint of developers/builders (especially in the case of less-capitalized developers/builders), the main justification for selling presales is to share some of the project uncertainty or risks with investors by diminishing the amount of capital required for the project and of course to reduce the liquidity risk. For housing buyers, signing a presale contract provides at least three benefits: avoiding the risk of the housing price rising in the future (by locking in the purchase price),

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decreasing the burden in the initial period, and owning the real option of giving up the housing purchase. However, from the viewpoint of the real estate market, presales serve as a vehicle for price discovery for to-be-built dwellings because the presale price contains information about expectations regarding future existing houses and inflation. The presale price and transaction volume signal future housing market conditions and can be utilized to observe housing cycles.

Real estate finance studies often analyze the presale price by adopting two categories of derivatives: call option and forward/futures. The former is based on the viewpoints of developers and/or purchasers and treats the presales as investing instruments.[1] However, this paper attempts to start from the viewpoint of the housing market and thus handles the presale as a forward or futures contract (e.g., Chang and Ward, 1993; Hua, Chang, and Hsieh, 2001; Wong et al., 2006; Leung, Hui, and Seabrooke, 2007; Edelstein, Liu, and Wu, 2012; Tsai, Chen, and Chiang, 2014; Lee, Lee, and Lin, 2014; Fu, Qian, and Yeung, 2016) while treating the existing housing as the spot market. To deal with the characteristic of price convergence of presale and existing houses, a Brownian bridge process is first applied to the real estate market in this paper.

Furthermore, studies have identified significant relations between existing houses and macroeconomic factors (see the review in Leung, 2004, 2019). Chang and Ward (1993) also indicate that the basis price (defined as the spot price minus presale price) is affected by expectations in the housing cycle. As a result, like the price discovery function of futures, it is believed that the basis price might reflect expectations regarding the future housing cycle. The basis price should thus be stochastic (rather than constant) and be affected by macroeconomic variables and the existing stock of houses. This paper therefore extends the modified Brownian bridge process to consider the time-varying volatility and possible influence of macroeconomic factors. While taking macroeconomic factors into consideration, however, the influence of the covariance structure of existing houses and macroeconomic factors and that of the stochastic basis price on the presale price has not been extensively studied.

To summarize, the triggering motivation of this paper is to employ presales as tools to manage housing risk. We provide a pricing model for presale contracts to address the influence of macroeconomic factors on expectations regarding the housing cycle and examine the basis risk by utilizing unbiased futures pricing. Considering the co-movement of macroeconomic factors with respect to existing houses and assuming that the stochastic basis price functions as a modified Brownian bridge process with macroeconomic factors taken into consideration, the closed-form solutions for the basis price and presale price are provided. Developers could refer to our method and infer the appropriate selling price of presales.

In addition, the finding reveals an asymmetric effect of macroeconomic factors on the presale price in different market conditions. Macroeconomic factors have more influence in a depressed housing market than in a booming housing market. Moreover, the influence of macroeconomic variables is greater on the basis price than on the prices of existing houses, especially in a depressed housing market. Specifically, after a recessionary period in a housing market, macroeconomic factors, e.g., inflation, stock returns, and construction cost, among many others, would play a crucial role influencing the presale market. In contrast, in a booming housing market, rather than just the macroeconomic factors, other microeconomic factors of the presale market should be taken into consideration, such as housing quality and location, individual expectations of future market

prices, and other product features. The above-mentioned results imply that macroeconomic variables may have different levels of influence on the markets for presale and existing houses, emphasizing the importance of considering basis risk and the influence of macroeconomic factors when pricing presale houses to manage house risk.

The remainder of this paper is organized as follows. The next section provides a literature review. Section 3 sets up our models and presents the closed-form formulas for basis risk and the presale price. Section 4 discusses the sensitivity analysis. Section 5 summarizes the paper and identifies implications.

Literature Review

Chan, Fang, and Yang (2008) suggest that although research on Asian property markets has increased, presale housing has not received significant attention in the academic literature. Despite its complexity, the presale transaction has been popular in many Asian countries for at least five decades. For example, the pre-sales housing system in Taiwan began with the "United Village 2" project in 1966 (Tsai, Chen, and Chiang, 2014). Via presale transactions, builders are allowed to sell housing units while the projects are still at the planning stage or immediately after obtaining the building permits (Hua Chang, and Hsieh, 2001).[2] As mentioned previously, the presale method provides significant benefits for developers, buyers, and loan lenders, but it also brings risk-shifting effects, as developers rarely abandon a presale project, and buyers typically do not decide not to complete a presale contract. Moreover, the presale method recently gained attention in the U.S. as residential property prices surged during the 2005–2006 housing boom.

Futures/Forward Pricing Stream

With the development of the real estate presale market, it is necessary to provide more discussions for presales and managing housing-related risk. Lee, Lee, and Lin (2014) state that presale housing markets are similar to forward or futures markets and are more likely to attract informed investors. Many earlier studies, such as Chang and Ward (1993), Hua, Chang, and Hsieh (2001), Wong et al. (2006), and Leung, Hui, and Seabrooke, (2007), use the approach of forward/futures contracts and investigate the impact of the presale market on housing supply adjustment, housing prices, and real estate risk hedging.[3] Chang and Ward (1993) further discuss the basis price and analyze how it varies based on expectations regarding the housing cycle, the quality/location of the housing, and other product characteristics by using static analysis. Leung, Hui, and Seabrooke (2007) regard property developers as having increasingly used forward contracts to presell uncompleted properties to enhance their financial viability. They propose 'forward risk' and employ linear regression to model the presale contract price to capture the risks of market uncertainty and asymmetric information.

Edelstein, Liu, and Wu (2012), Tsai, Chen, and Chiang (2014) and Fu, Qian, and Yeung (2016) also adopt a viewpoint regarding the presale as a forward contract. Edelstein, Liu, and Wu (2012) propose three theoretical models that explore the role that presale real estate contracts play in the pricing and risk hedging of residential real estate. In their work, Models I and II examine presale contracts as standard forward contracts. Tsai,

Chen, and Chiang (2014) use the Taiwan housing price indices from pre-sale markets as forward prices to examine the housing price rigidity and asymmetric price adjustments of housing markets. Fu, Qian, and Yeung (2016) consider that a presale resembles a forward contract whereby the developer undertakes to deliver the project according to specifications within a specified time period (usually approximately three years from the commencement of construction), and the buyer is obliged to pay a predetermined price at the time of purchase.

Option Pricing Stream

The second strand of the literature treats presales as call option contracts and addresses issues such as the operating strategies and pricing of presale transactions from the viewpoints of the developers or purchasers.[4] Lai, Wang, and Zhou (2004) lay the foundation for a real option and examine the problem from the perspectives of purchasers and developers in which both parties demand a risk-free rate of return on their investments. They analyze property price data from Shanghai, Hong Kong, and Taipei and surmise that property prices could be modeled using the geometric Brownian motion (GBM) method. Chan, Fang, and Yang (2008) also use the options approach and extend the literature by applying a simple equilibrium model to presale contracts under the assumption that property prices are normally distributed. Choi, Rasmussen, and Davison (2012) assume that property prices follow a GBM rather than a normal distribution. Choi, Rasmussen, and Davison (2012) also allow for uncertainty with regard to construction costs by treating them as a stochastic variable, whereas Chan, Fang, and Yang (2008) assume that construction costs are deterministic.

Most existing models for pricing presale contracts assume that the property price process follows GBM. However, this assumption only considers the randomness of the property prices themselves; it ignores co-movement between property prices and macroeconomic factors. Without taking the co-movement into account, these models might be unable to capture or forecast precisely the pattern of property prices or the pricing of presale houses based on the information regarding macroeconomic factors. Many studies empirically highlight the significant relationship between macroeconomic factors and real estate returns.[5] For instance, McCue and Kling (1994) show that macroeconomic factors explain nearly 60% of the series variation in real estate. Green (2002) and Chen and Patel (2002) also demonstrate that stock return dynamics are a key determinant of existing house trends. In addition, from a housing supply perspective, construction costs, and land acquisition significantly influence the cost of houses. Jud and Winkler (2002) find that appreciation in real housing prices is strongly positively related to increases in construction costs. Grimes and Aitken (2010) indicate that an increase in land costs or construction costs can reduce the new housing supply, which in turn increases housing prices.

Model Setup

To examine the basis and presale prices, we first describe the dynamics of the existing houses and the interest rate to consider the effect of macroeconomic factors on existing

houses. We further employ the modified Brownian bridge process to model the stochastic basis price with the stochastic interest rate to capture the risk of expectations in the housing cycle. Finally, we provide the closed-form solutions of basis price and presale price in a risk-neutral world.

Model of Existing Houses and the Interest Rate

Several empirical studies (e.g., Abraham and Hendershott, 1996; Muellbauer and Murphy, 1997; Leung, 2004; Oikarinen, 2009; Chen et al., 2012; Wei et al., 2013) have indicated that a significant relationship exists between housing price and macroeconomic factors. To capture the effects of interest rate and the other macroeconomic factors on the housing market, the existing houses are modeled as a multifactor stochastic process, where n macroeconomic factors follow a geometric Brownian motion. The interest rate follows an extended Vasieck model and is correlated with the price of existing houses. Applying methods developed by Rubinstein (1976) and Brennan (1979), the discount values of existing houses and macroeconomic factors become martingales under a risk-neutral valuation relationship. From the physical measure to the risk-neutral measure Q, the expected returns for the existing houses shift according to the risk-free interest rate, but the covariance structure remains unchanged. Through algebraic rearrangement, the price of existing houses $H(t)$ under the risk-neutral measure Q can be obtained from the following expression:[6]

$$\frac{dH(t)}{H(t)} = r(t)dt + \tilde{\sigma}_H \cdot dW^Q(t) + \sum_{i=1}^{n} c_i \tilde{\sigma}_{M_i} \cdot dW^Q(t), \tag{1}$$

and the dynamics of the interest rate under the risk-neutral measure Q are as follows:

$$dr(t) = k[\theta - r(t)]dt + \tilde{\sigma}_r \cdot dW^Q(t), \tag{2}$$

$$dW^Q(t) = \begin{bmatrix} dW_H^Q(t) \\ dW_r^Q(t) \\ dW_{M_i}^Q(t) \\ dW_Z^Q(t) \end{bmatrix}, \tilde{\sigma}_H = \sigma_H \times \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \tilde{\sigma}_r = \sigma_r \times \begin{bmatrix} \rho_{Hr} \\ \sqrt{1-\rho_{Hr}^2} \\ 0 \\ 0 \end{bmatrix}, \tilde{\sigma}_{M_i} = \sigma_{M_i} \times \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix},$$

where $r(t)$ represents the interest rate at time t. c_i denotes the sensitivity parameter for macroeconomic factor M_i on the existing houses. $\tilde{\sigma}_H^2$ ($\tilde{\sigma}_{M_i}^2$, $\tilde{\sigma}_r^2$) denote the variance of standard Brownian motion for existing houses (i^{th} macroeconomic factor, the interest rate). $W^Q(t)$ stands for a multidimensional standard Brownian motion with a filtered probability space $(\Omega, F, Q, (F_t)_{t=0}^T)$. F_t, $t \in [0, T]$ is the smallest sigma field such that $H(t)$, $M_i(t)$ and $r(t)$ are measurable; and $(F_t)_{t=0}^T$ is the right-continuous natural filtration. $W_H^Q(t)$, $W_{M_i}^Q(t)$, and $W_Z^Q(t)$ is a Wiener process for the existing houses, macroeconomic factors, and basis price. $E(W_{M_i}^Q(t)W_{M_j}^Q(t)) = \rho_{M_iM_j}(t)$, $i, j = 1, 2, \ldots, n$. Furthermore, $W_r^Q(t)$ is a Wiener process for the interest rate, and $E(W_H^Q(t)W_r^Q(t)) = \rho_{Hr}$ represents the correlation between the existing houses and the interest rate. For the sake of simplicity, we assume that $E(W_{M_i}^Q(t)W_r^Q(t)) = 0$. k and θ denote the mean-reverting force and the long-term mean of the interest rate, respectively.

According to Equation (1), the existing house return volatility is[7]

$$Var\left(\frac{dH(t)}{H(t)}\right) \equiv V(t) = \left(\tilde{\sigma}_H^2 + C\Sigma(t)C'\right)dt,$$

$C = [c_1, \ldots, c_n]'$, $\sum(t) = \left[\sigma_{M_iM_j}(t)\right]_{n\times n}$, and $\sigma_{M_iM_j}(t) = \rho_{M_iM_j}(t)\sigma_{M_i}(t)\sigma_{M_j}(t)$, $i, j = 1, 2, \ldots, n$. The total volatility of the existing houses $V(t)$ includes two components: the covariance matrix of the macroeconomic factors $\Sigma(t)$ and the volatility of the Wiener process for the existing houses $\tilde{\sigma}_H^2$. In addition to the volatilities $\tilde{\sigma}_H$ and $\tilde{\sigma}_{M_i}^2$, the existing house return is related to the coefficient c_j, which gauges the impact of macroeconomic factor M_j on the existing houses and the covariance structure of macroeconomic factors.

In the presence of a stochastic interest rate, a similar factorization can be obtained by performing a measure change to the forward-neutral measure P_T. Here, $f_P(t, T)$ is the forward price at time t, with maturity T satisfying

$$f_P(t, T) = \frac{H(t)}{B(t, T)}, t \leq T, \tag{3}$$

where $B(t, T)$ is the time t price of a zero coupon bond that pays one dollar at time T.

Assume that a unique forward risk-neutral measure P_T exists that is given by the following Radon-Nikodym derivative:[8]

$$\frac{dP_T}{dQ} = \exp\left\{\int_0^T b(u, T) \cdot dW^T(u) - \frac{1}{2}\int_0^T |b(u, T)|^2 du\right\}, \tag{4}$$

$$b(u, T) = \tilde{\sigma}_r/k\left[\exp\left(-k(T-u)\right) - 1\right], \tag{5}$$

where $|\cdot|$ denotes the Euclidean norm in R^4. $W^T(t)$ represents the multidimensional Brownian motion under the forward measure P_T. Hence, under the forward measure P_T, the forward price satisfies

$$f_P(T, T) = f_P(0, 0)\exp\left\{-\frac{1}{2}\int_0^T |\phi(u, T)|^2 du + \int_0^T \phi(u, T) \cdot dW^T(u)\right\}, \tag{6}$$

where $\phi(u, T) = \tilde{\sigma}_H + \Omega\sum^* C - b(u, T)$, and $\Omega = \left[\rho_{M_iM_j}\right]_{n\times n}$ is the variance-covariance matrix; $\sum^*$ is a diagonal matrix that satisfies $\sum^* = diag(\sigma_{M_1}, \ldots, \sigma_{M_n})$.

Stochastic Basis Price: Modified Brownian Bridge Process

Comparatively few methods of presale pricing have been discussed in the literature. Chang and Ward (1993) treat presales as forward contracts and examine the relationship between presale price and spot price, while Leung, Hui, and Seabrooke (2007) use linear regression to model the presale contract price. This paper proposes an alternative model of presale contract pricing by assuming that the stochastic process of basis behaves as a modified Brownian bridge process. Furthermore, we consider that the changes in the basis price (called basis risk) might be affected by the existing houses, the interest rate, and other macroeconomic factors. Following Yan (2002) and Liu and Longstaff (2004), the basis price $Z(t, U)$ is defined as the log futures price at time t with delivery date U

minus the log spot price at time t. Furthermore, we consider that the quality of a house decreases as it ages, depreciation rate per year equaling a portion α of its existing value. Hence, we have

$$Z(t,U) = \ln F(t,U) - \ln(1-\alpha)H(t) \tag{7}$$

The sign of basis price provides insight into signals of the expectation of a housing cycle. $Z(t,U)$ being positive implies that the housing cycle is expected to be booming, while the housing cycle is expected to be depressed when $Z(t,U)$ is negative.

The basis process can be assumed to follow a Brownian bridge process, which is therefore used to mimic the basis process directly. A Brownian bridge is a Brownian motion that will reach a specified point at a specified time. With the assumption of no arbitrage, the existing house and presale prices will converge at the maturity date; thus, the basis, which fluctuates prior to maturity, becomes zero at the maturity date. However, the volatility of the Brownian bridge process is only a function of time to maturity and fails to reflect the time variation in basis volatility. Hence, we extend Wang and Wu (2011)[9] in modifying the Brownian bridge process by time-varying volatility. Let the basis $Z(t,U)$ be a modified Brownian bridge in the time interval $[0,U]$ with $Z(0,U) = \ln F(0,U) - \ln(1-\alpha)H(0)$, and $Z(0,0) = 0$. Under the spot martingale measure P_Q, the basis process is defined as follows:

$$dZ(t,U) = \frac{-Z(t,U)}{U-t}dt + \tilde{\sigma}_Z(t,U)\cdot dW_Z^Q(t), \tag{8}$$

$$\tilde{\sigma}_Z(t,U) = \sigma_Z(t,U) \times \begin{bmatrix} \rho_{HZ} \\ \rho_{rZ}^* \\ \rho_{MZ}^* \\ \rho_Z^* \end{bmatrix},$$

$$\rho_{MZ}^* = \frac{\rho_{MZ} - \rho_{rZ}^*\rho_{rM}^*}{\sqrt{1-\rho_{HM}^2-\rho_{rM}^{*2}}}, \rho_Z^* = \sqrt{1-\rho_{HZ}^2-\rho_{rZ}^{*2}-\rho_{MZ}^{*2}}, \rho_{ri}^* = \frac{\rho_{ri}-\rho_{Hr}\rho_{Hi}}{\sqrt{1-\rho_{ir}^2}}, i = ZorM, \tag{9}$$

where $\tilde{\sigma}_Z(t,U)$ is the time-varying basis volatility including the relationship among the existing houses, the interest rate, and other macroeconomic factors. $\sigma_Z(t,U)$ is the time-varying initial basis volatility; ρ_{rZ} (ρ_{HZ}, ρ_{MZ}) is the correlation coefficient of the interest rate (the existing houses and macroeconomic factors) and the initial basis price; $\rho_{Hr}(\rho_{Mr})$ is the correlation coefficient of the existing houses (macroeconomic factors) and the interest rate; and ρ_{HM} is the correlation coefficient of the existing houses and macroeconomic factors. W_Z^Q represents a one-dimensional Brownian motion defined on the filtered probability space (Ω, F, P_Q). Based on the specifications in Equations (8) and (9), the modified Brownian bridge process considers the basis volatility and allows for interactions among the existing houses, the interest rate, the other macroeconomic factors, and the initial basis price.

Closed Form Solutions: Basis Price and Presale Price

As shown by Klebaner (1998), $Z(t,U)$ is equal to zero as t approaches U. The solution is presented as follows:[10]

$$Z(t,U) = \frac{(U-t)Z(0,U)}{U} + \int_0^t \sigma_Z^*(t,U) \cdot b(u,U)du + \int_0^t \sigma_Z^*(t,U) \cdot dW^T(u), \tag{10}$$

where $\sigma_Z^*(t,U) = \frac{(U-t)\tilde{\sigma}_Z(t,U)}{U-u}$.

According to the above equation, the conditional expected value of the basis process at time t is

$$E(Z(t,U)|F_t) = \frac{(U-t)Z(0,U)}{U} + \int_0^t \sigma_Z^*(t,U) \cdot b(u,U)du, \tag{11}$$

which is a function of the initial basis price $Z(0,U)$, the basis volatility $\tilde{\sigma}_Z(t,U)$ and the parameter of the interest rate $b(u,U)$ during the time to maturity $U-t$.

The closed-form solution obtained from the presale price-basis risk approach is presented as follows. Based on Equation (6), the presale $F(t,U)$ equals $H(t)$ multiplied by the exponential of $Z(t,U)$ and satisfies

$$F(T,U) = f_P(0,T)\exp\left\{Z(T,U) - \frac{1}{2}\int_0^T |\phi(u,T)|^2 du + \int_0^T \phi(u,T) \cdot dW^T(u)\right\}. \tag{12}$$

The mean of the presale price, taking into account the basis risk, which is computed using the moment-generating function method, is as follows:

$$E(F(T,U)) = \frac{F(0,U)}{B(0,T)}\exp\left[\gamma(0,T,U)\right], \tag{13}$$

where

$$\gamma(0,T,U) = \frac{-TZ(0,U)}{U} + \frac{1}{2}\sigma_F^2(0,T,U) + \int_0^T \left[\sigma_Z^*(T,U) \cdot b(u,U) - \frac{1}{2}|\phi(u,T)|^2\right]du,$$

$$\sigma_F^2(0,T,U) = \int_0^T \left|\sigma_Z^*(T,U) + \phi(u,T)\right|^2 du. \tag{14}$$

Two important characteristics are crucial to the presale price process. First, the basis price is both random and zero at maturity. Second, the expectation value in the presale price is a function of the initial presale price, the initial basis price, the existing house volatility, macroeconomic factors at play, and the interest rate. Correlations also exist among the basis, the existing houses, the interest rate, and macroeconomic factors. In particular, the variance of the presale price $\sigma_F^2(0,T,U)$ includes two risk components: (1) The basis risk ($\tilde{\sigma}_Z(t,U)$), reflecting the risk of the expectations in the housing cycle, depends on the correlations among the basis, existing houses, interest rate, and macroeconomic factors. (2) The risk of the forward existing house return $\varphi(u,T)$, reflecting the co-movement risk of the existing houses and macroeconomic factors, depends on the covariance matrix of macroeconomic factors, the volatility of the existing house residuals, and the relationship between the existing houses and the correlation coefficients of the macroeconomic factors.

Table 1. Model parameters and their descriptions.

Variable	Definition	Value
Existing house parameters		
μ_H	Drift	0.0006
$\tilde{\sigma}_H$	Standard deviation of existing house returns	0.0793
α	Depreciation rate of existing house prices	0.0525
Macroeconomic factor parameters		
$\Delta \ln LP$	Land price change rate	4.8535
$\Delta \ln CC$	Construction cost change rate	4.0907
INF	Inflation rate	0.0118
σ_{M_1}	Standard deviation of land price change rate	0.0102
σ_{M_2}	Standard deviation of construction cost change rate	0.0056
σ_{M_3}	Standard deviation of inflation rate	0.3963
$\rho_{M_1M_2}$	Correlation of land price change rate and construction cost change rate	0.3468
$\rho_{M_1M_3}$	Correlation of land price change rate and inflation rate	0.1570
$\rho_{M_2M_3}$	Correlation of construction cost change rate and inflation rate	0.1569
Interest rate parameters		
$\tilde{\sigma}_r$	Volatility parameter for the interest rate	0.1845
k	Mean-reverting force measurement	0.098
θ	Long-term mean of the interest rate	0.021
Basis parameters		
$Z(0,U)$	Initial basis price	Variable
σ_Z	Initial basis volatility	Variable
ρ_{rZ}	Correlation coefficient between the interest rate and the basis	Variable
ρ_{HZ}	Correlation coefficient between existing houses and the basis	Variable
ρ_{MZ}	Correlation coefficient between the macroeconomic factors and the basis	Variable
ρ_{Hr}	Correlation coefficient between existing houses and the interest rate	Variable
ρ_{Mr}	Correlation coefficient between the macroeconomic factors and the interest rate	Variable
ρ_{HM}	Correlation coefficient between existing houses and the macroeconomic factors	Variable
Other parameters		
$F(0,U)$	Initial price of presale	Variable
$B(0,T)$	Time price of a zero-coupon bond paying one dollar at time T	0.97
$U-T$	Time to maturity of presale	Variable

Sensitivity Analysis

Data Description

Before starting the sensitivity analysis, the existing house parameters, the macroeconomic factors, and the basis should be obtained. For the existing house parameters and macroeconomic factors, we refer to the works of Chang et al. (2012) and Chen et al. (2012) to implement the preliminary empirical procedures. The sample covers the period from January 1987 to June 2018, including 378 monthly observations. S&P/Case-Shiller Home Price Indices are employed as a proxy for housing prices in the U.S. real estate market. The significant macroeconomic factors for housing returns are the log changes in land prices ($\Delta \ln LP$), the log changes in construction costs ($\Delta \ln CC$), and the changes in the real mortgage rate (ΔRMR). The 3-month U.S. Treasury Bill is selected as the proxy of interest rate and is available from the Federal Reserve Economic Data (FRED) database. All variables measured in nominal terms are deflated by the consumer price index (CPI), which is also available from the FRED database. We borrow the estimations from Jeffrey et al. (2005) to set the depreciation rate per year of existing house prices α at 5.25%. The detailed descriptions of model parameters are summarized in Table 1.

What Influence Basis Price Should Be Changed?

To analyze how the basis price is affected by some critical factors in this subsection, we derive the sensitivities of the conditional expected value of the basis process to the initial basis price, the initial basis volatility, the interest rate, and the time to maturity as follows:

$$\frac{\partial E(Z(t,U)|F_t)}{\partial Z(0,U)} = \frac{U-t}{U} > 0, \tag{15}$$

$$\frac{\partial E(Z(t,U)|F_t)}{\partial \sigma_Z(t,U)} = (U-t)\int_0^t \frac{b(u,U)\left(\rho_{HZ} + \frac{\rho_{rZ}-\rho_{Hr}\rho_{HZ}}{\sqrt{1-\rho_{Hr}^2}} + \rho_{MZ}^* + \rho_Z^*\right)}{U-u} du. \tag{16}$$

$$\frac{\partial E(Z(t,U)|F_t)}{\partial b(u,U)} = (U-t)\int_0^t \frac{\tilde{\sigma}_Z(t,U)}{U-u} du, \tag{17}$$

$$\frac{\partial E(Z(t,U)|F_t)}{\partial (U-t)} = \frac{Z(0,U)}{U} + \int_0^t \frac{\tilde{\sigma}_Z(t,U)\cdot b(u,U)}{U-u} du - \frac{\tilde{\sigma}_Z(t,U)\cdot b(t,U)}{U-t}. \tag{18}$$

Based on Equations (15) to (18), we find that the conditional expected value of the basis process is an increasing function of the initial basis price, whereas it is an uncertain function of the volatility of the basis process, the interest rate, and the time to maturity. The result in Equation (15) indicates that the initial basis price being higher implies that the investors expected that the housing market would be more bullish and thus that the conditional expected value of the basis price (the difference due to the presale price being higher than the existing houses) would be larger. The relationship between the conditional expected value of the basis process and the volatility of the basis process (the interest rate and the time to maturity) depends on the initial basis price, the time to maturity, and the relationships among existing houses and macroeconomic factors. For instance, according to the cost of carry theory, the higher the interest rate and the longer the construction time-lag, the greater is the discount required in presales and the greater is the basis price (i.e., $\rho_{rZ} > 0$).

The graphical numerical results in Figures 1 and 2 show that the conditional expected value of the basis price is an increasing function of the correlation coefficient for the existing houses (macroeconomic factors) and the initial basis price. However, the sign of the correlation coefficient for the existing houses (macroeconomic factors) and the initial basis price determines the relationship between the basis volatility and the basis price. When ρ_{HZ} (ρ_{MZ}) equals -0.5, the conditional expected value of the basis price is negatively related to the basis volatility. When ρ_{HZ} (ρ_{MZ}) is positive, the conditional expected value of the basis price is positively related to the basis volatility. This result implies that, in a booming housing market (where the initial basis price is positive, $Z(0,U) = 60$), if ρ_{HZ} (ρ_{MZ}) is positive, the expectations are such that the housing cycle will be booming in the future. When the housing cycle is expected to be booming, the conditional expected value of the basis price will increase.

Furthermore, as the volatility of the initial basis price increases, the expectations of a booming housing cycle lead to the conditional expected value of the basis price being increased. On the other hand, a large and negative ρ_{HZ} (ρ_{MZ}) implies that the expectations regarding the housing cycle are lowered in the future. Hence, when the volatility of the initial basis price increases, the lowered expectations regarding the housing cycle

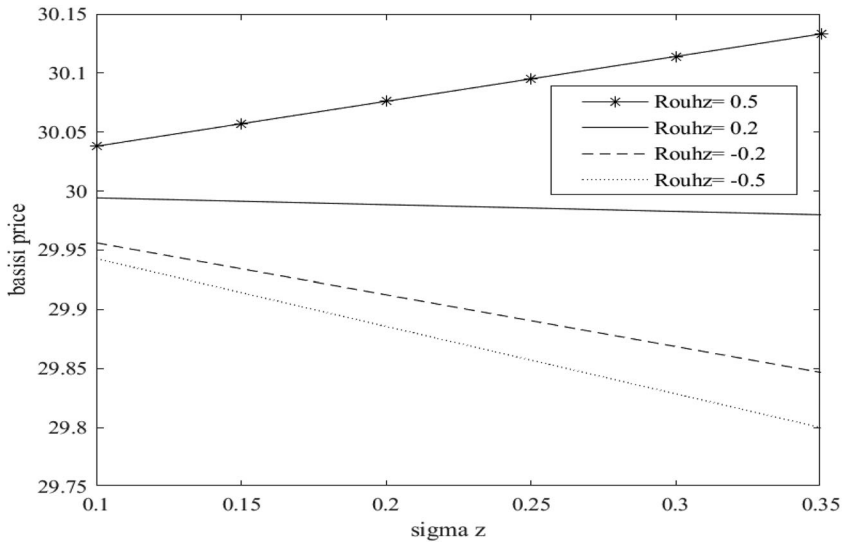

Figure 1. The impacts of the initial basis volatility and the correlation coefficient between the existing houses and the initial basis price on the conditional expected value of the basis process.
Note. The conditional expected value of the basis process in Equation (11) are computed by using $\rho_{rZ}=-0.2$, $\rho_{HZ}=-0.2$, $\rho_{Hr}=-0.2$, $\rho_{Mr}=-0.2$, $\rho_{HM}=-0.2$, $F(0,U)=115.7$, $U-T=5$, $Z(0,U)=60$.

lead to a decrease in the volatility of the basis price and to a reduction in the conditional expected value of the basis price. Finally, we find that as the correlation coefficient of the existing houses and macroeconomic factors is reduced from positive to negative (i.e., the expectations regarding the housing cycle are lowered), the increment of the conditional expected value of the basis price is increased, especially as reflected in the larger volatility of the initial basis price.

As indicated by Equation (18), the sign of the effect of the time to maturity on the basis price depends on the ratio of the initial basis price to the time to maturity and the relationships between the initial basis price, the existing houses, the interest rate, and the macroeconomic factors. Figure 3 depicts the relationships among the ratio of the initial basis price to the time to maturity, the correlation coefficient for the macroeconomic factors and the initial basis price, and the effect of the time to maturity on the basis price. We find that the effect of the time to maturity on the basis price mainly depends on the ratio of the initial basis price to the time to maturity. Regardless of whether the correlation coefficient for the macroeconomic factors and the initial basis price is positive or negative, when the ratio of the initial basis price to the time to maturity is negative (positive), the effect of the time to maturity on the initial basis price will be negative (positive). The result implies that if the initial basis price is positive, the housing cycle is encountering a boom. Thus, when the time to maturity of the presale contracts increases, the opportunity for the developer to pump money increases; this increase causes the conditional expected value of the presale price to rise. The conditional expected basis price then increases. On the other hand, if the initial basis price is negative, then the housing cycle is in a weak or depressed situation; thus, when the time to the maturity of the presale contracts increases, this situation makes the uncertainty or

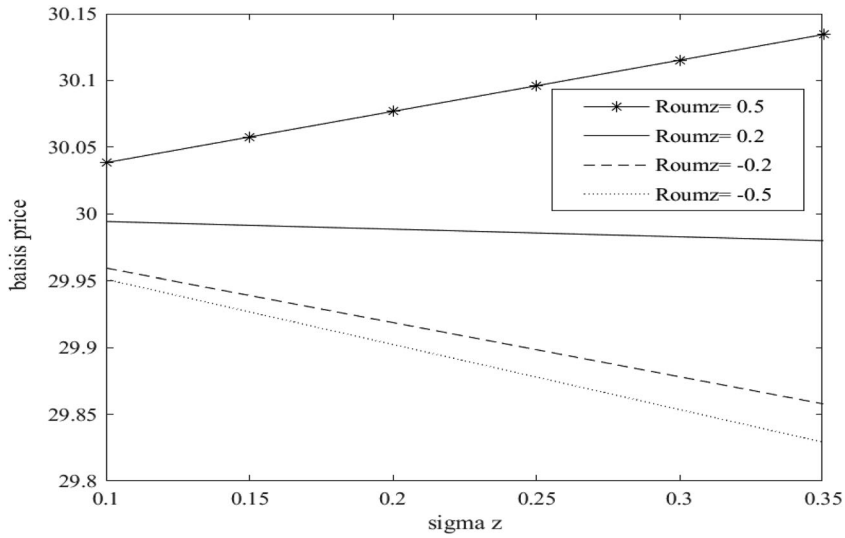

Figure 2. The impacts of the initial basis volatility and the correlation coefficient between the macroeconomic factor and the initial basis price on the conditional expected value of the basis process.
Note. The conditional expected value of the basis process in Equation (11) are computed by usingρ_{rZ}=−0.2, ρ_{HZ}=−0.2, ρ_{Hr}=−0.2, ρ_{Mr}=−0.2, ρ_{HM}=−0.2, $F(0,U)$=115.7, $U-T$=5, $Z(0,U)=60$.

risk of the project increase. The conditional expected value of the presale price then declines, and the conditional expected value of the basis price also falls.

What Influences Presale Price to Change?

To analyze the characteristics of presale pricing, in this subsection, we derive their sensitivities from the conditional expected value of the presale price relative to the initial presale price, the initial basis price, and the variance of the initial basis price as follows:

$$\frac{\partial E(F(T,U))}{\partial F(0,U)} = \frac{\exp\left[\gamma(0,T,U)\right]}{B(0,T)} > 0, \tag{19}$$

$$\frac{\partial E(F(T,U))}{\partial Z(0,U)} = \frac{F(0,U)}{B(0,T)}\exp\left[\gamma(0,T,U)\right]\frac{-T}{U} < 0, \tag{20}$$

$$\frac{\partial E(F(T,U))}{\partial \sigma_Z^2} = \frac{F(0,U)}{B(0,T)}\exp\left[\gamma(0,T,U)\right]\frac{\partial \gamma(0,T,U)}{\partial \sigma_Z^2}. \tag{21}$$

$$\frac{\partial E(F(T,U))}{\partial \rho_{iZ}} = \frac{F(0,U)}{B(0,T)}\exp[\gamma(0,T,U)]\frac{\partial \gamma(0,T,U)}{\partial \rho_{iZ}}, i = MorH. \tag{22}$$

Based on Equations (19) to (22), we find that the conditional expected value of the presale price is an increasing function of the initial presale price, whereas it is a negative function of the initial basis price. The results of Equations (19) and (20) indicate that, ceteris paribus, a higher initial presale price implies that the presale market is exhibiting optimism, thus leading the expected value of the future presale price to rise. Moreover, when the initial presale price is unchanged, a higher initial basis price will result in a

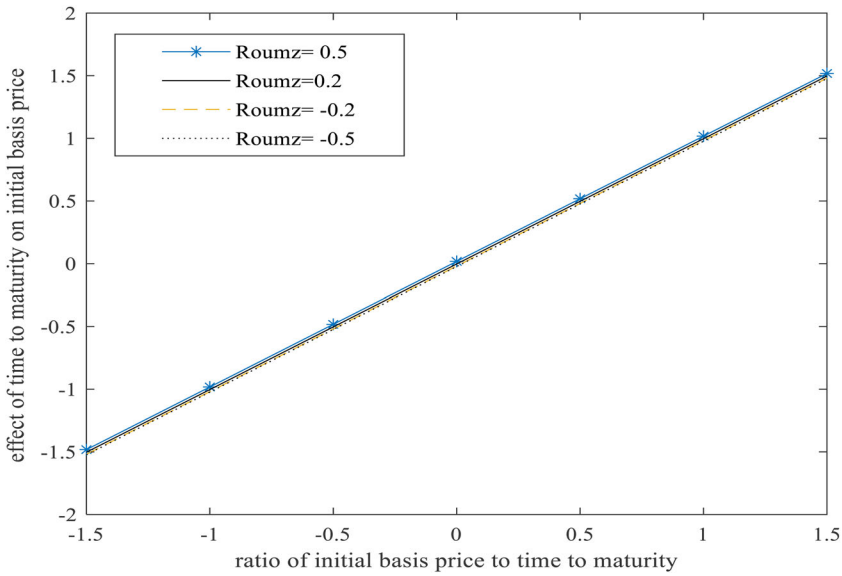

Figure 3. Relationship among ratio of initial basis price to time to maturity, the correlation coefficient between the macroeconomic factor and the initial basis price and the effect of time to maturity on initial basis price.

Note. The effect of time to maturity on initial basis price in Equation (18) are computed by using $\rho_{rZ}=-0.2$, $\rho_{HZ}=-0.2$, $\rho_{Hr}=-0.2$, $\rho_{Mr}=-0.2$, $\rho_{HM}=-0.2$, $F(0,U)=115.7$.

lower existing house level, which will cause the conditional expected value of the presale price to decrease. In particular, the relationship between $F(0,U)$ and σ_Z^2 (or ρ_{iZ} $, i = MorH$) depends on the relationships between the existing houses, the interest rate, and the other macroeconomic factors at play.

Exhibits 5 and 6 show that the conditional expected value of the presale price is a decreasing function of the correlation coefficient for the existing houses (macroeconomic factors) and the initial basis price; however, the sign of the correlation coefficient for the existing houses (macroeconomic factors) and the initial basis price determines the relationship between the basis volatility and the conditional expected value of the presale price. When ρ_{HZ} (ρ_{MZ}) is negative, the conditional expected value of the presale price is positively related to the initial basis volatility. When ρ_{HZ} (ρ_{MZ}) is positive, the conditional expected value of the presale price is negatively related to the basis volatility. Hence, we find that these effects on the presale price contrast with those on the basis price. A possible reason is that when ρ_{HZ} (ρ_{MZ}) increases, the volatility of the basis price increases, whereas the volatility of the presale price decreases; thus, the conditional expected value of the presale price is reduced.

Figure 6 depicts the relationships between the initial basis price, the correlation coefficient for the macroeconomic factors, and the conditional expected value of the basis price and the presale price. This figure shows that the conditional expected value of the presale price is a decreasing function of the initial basis price. When the initial presale price is unchanged, a higher initial basis price will result in a lower existing house level, which will cause the conditional expected value of the presale price to decrease. Furthermore, we find that the relative level of the initial basis price has an asymmetrical

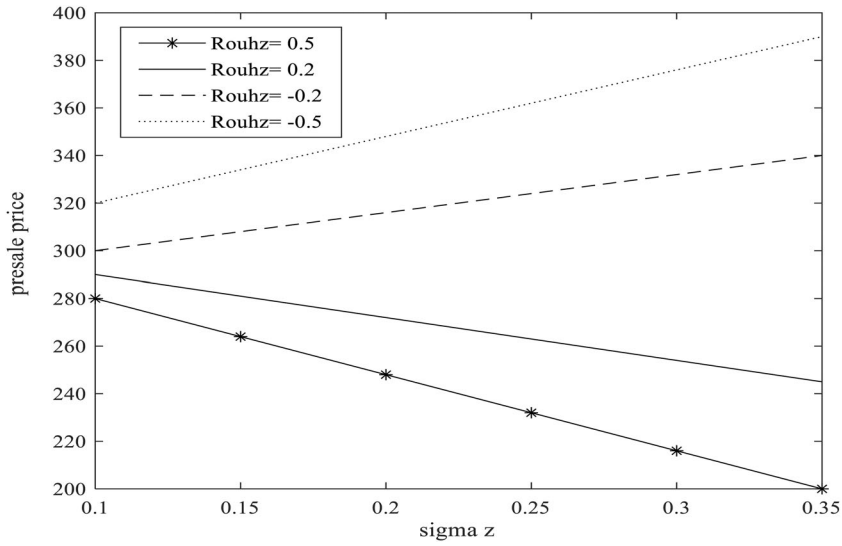

Figure 4. The impacts of the initial basis volatility and the correlation coefficient between the existing houses and the initial basis price on the conditional expected value of the presale price.
Note. The conditional expected value of the presale price in Equation (13) are computed by using ρ_{rZ}=−0.2, ρ_{HZ}=−0.2, ρ_{Hr}=−0.2, ρ_{Mr}=−0.2, ρ_{HM}=−0.2, $F(0,U)$=115.7, $U-T$=5, $Z(0,U)=60$.

effect on the conditional expected value of the presale price. When a negative initial basis price is increased, the increase in the conditional expected value of the presale price will be greater than when a positive initial basis price increases. We also find that the conditional expected value of the presale price is negatively related to the correlation coefficient for the macroeconomic factors and the basis price. For instance, in a depressed market (where the initial basis price is negative, $Z(0,U)=-20$), when $\rho_{MZ}=-0.5$, the housing cycle is by implication expected to reverse to exhibit a booming trend; thus, the conditional expected value of the presale price will rise. Finally, this figure shows the asymmetrical effect in which case macroeconomic factors have more influence in a depressed housing market than in a booming housing market on the conditional expected value of the presale price. Such results might reflect the effects of the investors' over-reaction and/or over-pessimism behaviors (Figures 4–6).

Which Risk is Greater for the Presale Price?

We compare three cases to examine how the risk of expectation in a housing cycle and the co-movement risk of existing houses and macroeconomic variables affect the conditional expected value of the presale price and further discuss which risk is greater for the presale price.

Case 1: General Case

According to Equation (14), we have that the variance in the presale price, $\sigma_F^2(0,T,U)=\int_0^T|\sigma_Z^*(t,U)+\phi(u,T)|^2du$, is influenced by the basis risk (reflecting the risk of the

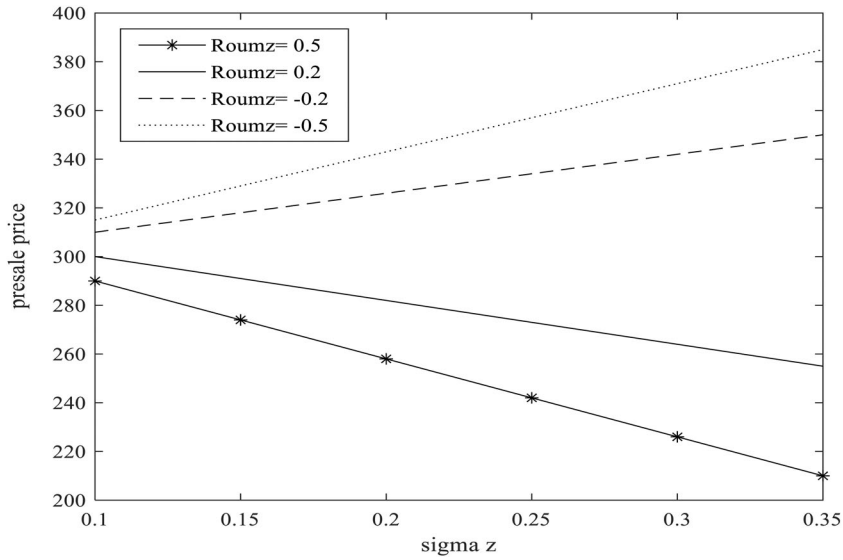

Figure 5. The impacts of the initial basis volatility and the correlation coefficient between the macroeconomic factor and the initial basis price on the conditional expected value of the presale price.
Note. The conditional expected value of the presale price in Equation (13) are computed by using $\rho_{rZ}=-0.2$, $\rho_{HZ}=-0.2$, $\rho_{Hr}=-0.2$, $\rho_{Mr}=-0.2$, $\rho_{HM}=-0.2$, $F(0,U)=115.7$, $U-T=5$, $Z(0,U)=60$.

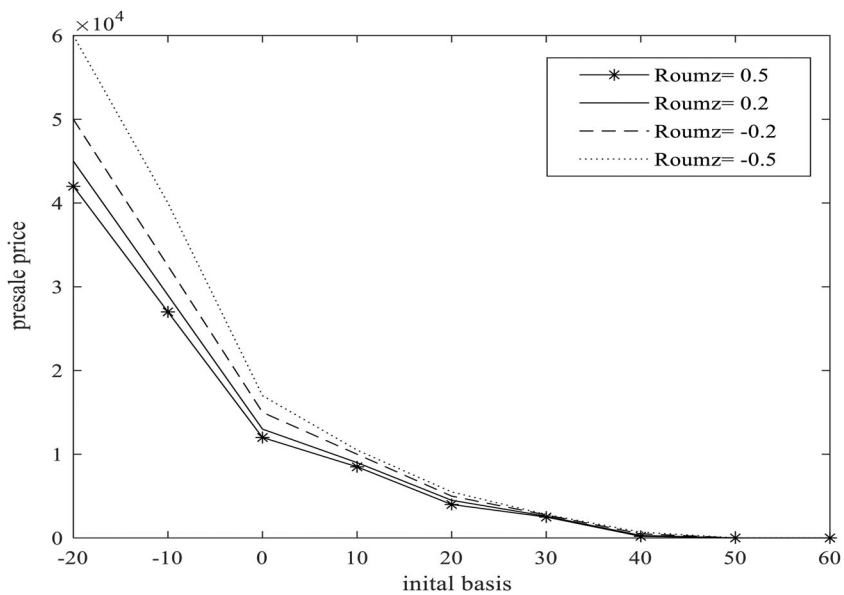

Figure 6. The impacts of the initial basis price and the correlation coefficient between the macroeconomic factor and the initial basis price on the conditional expected value of the presale price.
Note. The conditional expected value of the presale price in Equation (13) are computed by using $\rho_{rZ}=-0.2$, $\rho_{HZ}=-0.2$, $\rho_{Hr}=-0.2$, $\rho_{Mr}=-0.2$, $\rho_{HM}=-0.2$, $F(0,U)=115.7$, $U-T=5$, $Z(0,U)=60$.

expectation in the housing cycle), $\tilde{\sigma}_Z(t,U)$, and the risk of the forward existing house return (reflecting the co-movement risk of existing houses and macroeconomic variables), $\phi(u,T)$.

Case 2: Without Co-Movement Risk of Existing Houses and Macroeconomic Variables

Macroeconomic variables have a significant influence on the prices of real estate. To discuss the importance of considering the correlation between the existing houses and macroeconomic variables on the presale price, we provide the following special case where we ignore the effects of the macroeconomic variables on the forward existing house return based on Case 1. That is, $\phi(u,T) = \tilde{\sigma}_H - b(u,T)$; therefore, we have

$$\sigma_F^2(0,T,U) = \int_0^T |\sigma_Z^*(t,U) + \tilde{\sigma}_H - b(u,T)|^2 du. \tag{23}$$

Hence, by using Equations (13) and (23), the conditional expected presale price in this case can be computed. By comparing Case 1 and Case 2, we can further discuss how to influence the conditional expected presale price when ignoring the co-movement risk of existing houses and macroeconomic variables.

Case 3: Without the Risk of the Expectation in the Housing Cycle and the Co-Movement Risk of Existing Houses and Macroeconomic Variables

Many studies (e.g., Chang and Ward, 1993; Hua, Chang and Hsieh, 2001) indicate that the basis price is affected by the expectations of the housing cycle. Hence, we believe that the basis price is random rather than constant and is affected by the macroeconomic variables and existing houses. To discuss the importance of considering the correlation between the basis price and macroeconomic variables on the presale price, we further reduce Case 2 to ignore the risk of the expectation in the housing cycle (i.e., the conditional volatility of the basis price is zero; a constant basis price, $\tilde{\sigma}_Z(t,U) = 0, \phi(u,T) = \tilde{\sigma}_H - b(u,T)$). Thus, we have the following:

$$\sigma_F^2(0,T,U) = \int_0^T |\tilde{\sigma}_H - b(u,T)|^2 du. \tag{24}$$

Hence, by using Equations (13) and (24), the conditional expected presale price in this case can be computed. By comparing Cases 2 and 3, we can further discuss the mispricing of the variance of the presale price and the conditional expected presale price when ignoring the basis risk.

We show the corresponding conditional expected value of the presale price for each of the three cases in Figure 7. Figure 7 indicates that in each case, when the initial basis price is negative, the conditional expected value of the presale price in Case 2 differs from the value in Case 1; the maximum difference is approximately 1,000 index points. However, when the positive initial basis price increases, the conditional expected value of the presale price in Case 2 is almost the same as that in Case 1; the maximum difference is approximately 2 index points. It is possible that the conditional expected value of the presale price in Case 1 is lower than that in Case 2 because the negative correlations between the macroeconomic factors (i.e., the log changes in land prices, the log changes in construction costs, and the changes in the real mortgage rate) lead to a decrease in the presale price variance and the conditional expected value of the presale price.

Moreover, the differences between the presale prices in Cases 2 and 3 range from about 30 to 8,000 index points when the initial basis price changes from -20 to 60. A

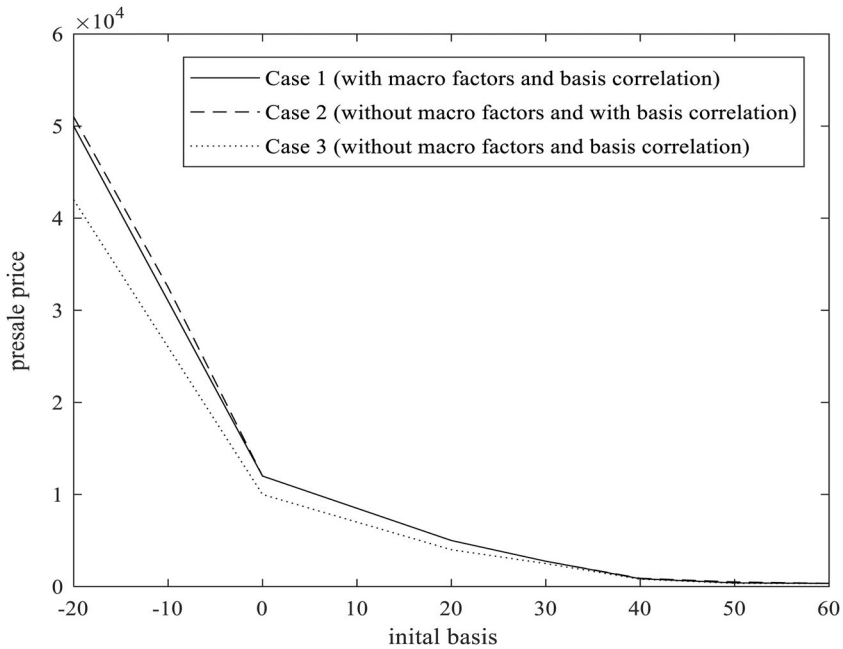

Figure 7. The comparisons of conditional expected value of presale price by different models.
Note. The conditional expected value of the presale price in Equation (21) are computed by using $\rho_{rZ}=-0.2$, $\rho_{HZ}=-0.2$, $\rho_{Hr}=-0.2$, $\rho_{Mr}=-0.2$, $\rho_{HM}=-0.2$, $F(0,U)=115.7, U-T=5$. The variance of the presale price in Case 1 is computed by Equation (14); the variance of the presale price in Case 2 is computed by Equation (22); the variance of the presale price in Case 3 is computed by Equation (23).

lower initial basis price yields a greater difference in the conditional expected value of the presale price. Hence, ignoring the impacts of macroeconomic factors on the existing houses and the basis price would lead us to severely underprice the conditional expected value of the presale price, particularly when the initial basis price is lower. Furthermore, when pricing presale contracts, the impact of macroeconomic factors on the basis price dominates that on the existing houses, especially in terms of the negative initial basis price. That is, the influences of the macroeconomic variables are more on the price differences between presale houses and existing houses than on the prices of existing houses. Such a result implies that there is a significant basis risk in the presale housing market. Consequently, when pricing presale contracts, we should take into account the significant basis risk in the presale housing market and the effect of macroeconomic factors on the basis price, especially in a depressed market.

Conclusions and Implications

Risk management in the real estate market is a crucial issue, especially after the subprime mortgage crisis. In light of recent developments, this paper uses the presale as a vehicle to manage housing risk. For presale pricing, rather than options pricing based on the views of builders or purchasers, this paper starts from the viewpoint of the housing market and employs futures pricing. The main contribution of this paper is to provide a

pricing model to examine the impact of macroeconomic factors on expectations regarding the housing cycle and then on differences in the prices of presale houses and existing houses. We first develop an existing house model to describe the relationship between housing prices and macroeconomic factors. The setting of this model is then able to capture precisely the pattern of property prices and the pricing of presale houses by considering the information from macroeconomic factors. Next, by using a modified Brownian bridge process with macroeconomic factors to model the stochastic basis price, we provide closed-form solutions for the basis and presale prices.

Our main findings indicate that the conditional expected value of the basis price is an increasing function of the expectations regarding the housing cycle, which is represented by the correlation of macroeconomic factors and the initial basis price. The sign of the correlation coefficient of the existing houses (macroeconomic factors) and the initial basis price determines the relationship between the basis volatility and the conditional expected value of the basis price. The results imply that the correlation of macroeconomic factors and the initial basis price should be considered in the expected basis risk of the price differences between presale houses and existing houses, in addition to the initial volatility reflecting the housing market disequilibrium on the supply and demand sides. Furthermore, the effect of time to maturity on the basis price mainly depends on the ratio of the initial basis price to the time to maturity rather than the sign of the correlation coefficient of macroeconomic factors and the initial basis price. Thus, when discussing the time effect of basis risk, we should take care to consider the effect of the housing cycle more than the effect of macroeconomic factors.

Concerning the main results of the presale pricing, we find that the expectations regarding the housing cycle and the macroeconomic factors have more influence in a depressed housing market than in a booming housing market on the conditional expected value of the presale price. Such results might reflect the investor behaviors of over-reaction and/or over-pessimism. These "asymmetric" results are also consistent with the results shown in Chang et al. (2012, 2013). Chen et al. (2015) further provide an expectation-based explanation. Furthermore, when pricing presale contracts, the influences of macroeconomic variables are more on the differences in the prices of presale houses and existing houses rather than on the prices of existing houses, especially in a depressed housing market.

Our results also suggest certain implications. First, we find that the influences of the macroeconomic variables have a significant impact on the basis and presale prices, particularly in a depressed housing market. Such a finding implies that macroeconomic variables may have different levels of influence on the markets for presale and existing houses. In particular, this difference will become greater when the housing market has slumped. Next, our formulas provide developers the reference selling price obtaining the required returns, which is inferred from the benchmark value of the presales under the risk-neutral world. In addition to considering the volatility of the presale housing market and the disequilibrium in the existing housing market, developers and investors should take more account of the significant basis risk in the presale housing market and the effect of macroeconomic factors on the basis price, especially in a depressed market. Finally, we find that, in a depressed housing market, macroeconomic factors are a crucial concern when entering the presale market. On the other hand, in a booming housing

market, we should take into consideration several other microeconomic factors regarding the presale market, such as the quality/location of the housing, heterogeneous consumer beliefs about future market prices, and product characteristics beyond just macroeconomic factors, when making a decision about presale contracts.

Notes

1. Fu, Qian, and Yeung (2016) state, 'the presale market is more attractive to short-term speculators than is the spot market for completed properties' since the holding cost is relatively low.
2. For more discussion of the presale system, please refer to Chan, Fang, and Yang (2014).
3. Wong et al. (2006) investigate the relationship between presale prices and existing condominium prices. Yiu, Wong, and Chau (2009) studied the impact of noise traders on the volume and price dispersion of presale contracts.
4. Some studies (e.g., Grenadier, 1995, 1996; Wang and Zhou, 2006; Lai, Wang, and Yang, 2007; Buttimer, Clark, and Ott, 2008) investigate the situation where buyers have the right to buy the property at a pre-determined exercise price and to default if the spot price falls below the contract price. Using a simple two-period game theoretical model, Chan, Wang, and Yang (2012) derive a closed-form pricing equation for a presale contract that explicitly accounts for a developer's abandonment option and a buyer's default option. Edelstein, Liu, and Wu (2012) create a set of interrelated theoretical models for explaining how and why developers and buyers engage in presale contracts for noncompleted residential dwellings.
5. See Leung (2004) for a review of macroeconomics and housing.
6. Some studies (e.g., Chen and Leung, 2008; Jin et al., 2012) show that the real estate price fluctuations in the variability of the capital market are confirmed to be significant. However, for simplicity in providing a pricing formula, we set the house price as the dependent variable and the macroeconomic factors as explanatory variables in the regression model, ignoring the possibly bidirectional relationship.
7. Chang et al. (2011, 2012, 2013) provide evidence that the house price, among other macroeconomic variables, displays regime-switching behaviors across several markets. Hence, our existing house return model (Equation 1) can be extended to multi-regime-type models. Based on the multi-regime-type models, the variance of existing house returns could capture the behaviors of different variances under different regimes.
8. Based on the stochastic interest rate, we use the forward neutral measure, in which a zero bond is used as the numeraire. With this numeraire, the martingale property holds. That is, today's value of an existing house is equal to the discounted expectation of its future value, taken with respect to the forward neutral measure. Hence, the price under the forward neutral measure is the fair price in a complete market. The gap between the fair price and actual price in the presale market is accompanied by the degree of imperfectness.
9. Wang and Wu (2011) use a two-factor (stochastic stock index and stochastic interest rate) model to describe the process of a futures contract.
10. For a similarly detailed derivation technique, see Klebaner (1998, p.121).

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