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Demand Uncertainty and Downward House Price Rigidity

Guan-Ru Chen[1], Plamen Patev[2]
[1]Professor, Department of Finance, I-Shou University, Taiwan
Email: dionysiac@isu.edu.twt
[2]Associate Professor, Department of International Finance, I-Shou University, Taiwan

Abstract

This study develops a price floor model to analyze how demand uncertainty affects pricing decisions. The model demonstrates that firms seeking to maximize profits, set quantity and a price floor prior to the resolution of uncertainty. Specifically, the model reveals downward price rigidity when faced with simultaneous slack demand and low construction costs, resulting in house price volatility that is lower than the volatility of actual demand. Downward house price rigidity carries significant macroeconomic and policy implications, affecting aggregate consumption, the effectiveness of monetary policy, and broader economic stability.

Keywords*: price rigidity, downward rigidity, house price, real estate, demand uncertainty*

1. Introduction

This study investigates the presence and dynamics of downward nominal house price rigidity. Understanding asymmetric price rigidity is crucial for comprehending housing market and macroeconomic dynamics, as well as the impact on household wealth and cost transmission. This asymmetry is a key departure from traditional flexible-price models and points towards specific market imperfections or behavioral biases that disproportionately affect downward adjustments. The "rockets and feathers" phenomenon, where prices ascend rapidly with cost increases but descend slowly with cost decreases, exemplifies this asymmetry, illustrating the non-linear nature of price adjustments in real estate (Rebelo et al., 2024). Building on the observation by Einiö, Kaustia, and Puttonen (2008) of a substantial fraction of repeat-sales with zero nominal price changes in Finland, Erlandsen and Juelsrud (2023) examine whether this phenomenon is more pronounced during housing market downturns, indicative of downward nominal house price rigidity. Using a long-term dataset of Norwegian housing data from 1850 to 2019, Erlandsen and Juelsrud (2023) reveal nominal price rigidity through a significant fraction of zero nominal price changes; and this fraction increases during housing market downturns, supporting the hypothesis of downward price rigidity.

For policymakers, recognizing this rigidity is crucial for designing effective interventions, such as monetary policy adjustments or targeted housing programs, to mitigate the adverse effects of housing market fluctuations and promote overall economic stability. If prices are slow to adjust downwards, it can prolong housing downturns. The market downturn did not improve affordability for aspiring homeowners who needed larger deposits to secure mortgage finance in the credit-constrained environment. (Gurran et al., 2015). In this study, we construct a model in which there are two variables to be solved. Instead of closed-form solutions, this study employs a numerical analysis which is called the Kuhn-Tucker finite dimensional method (Johannes, 2017) to obtain maximum-profit solutions. Numerical analysis has the advantage of coping with more general models with higher flexibility. The theoretical framework is built upon a two-period model where demand uncertainty, denoted by 'X', follows a binomial probability distribution, with its resolution occurring in the second period.[5] The manufacturer's profit maximization problem involves determining the optimal quantity (Q) and price floor (P), while accounting for construction costs (TC) and the salvage value (s) of any unsold units, which become relevant if demand turns out to be low and the flexible market price falls below the established floor. To derive the optimal values for price floor and quantity, the study employs a numerical analysis technique known as Kuhn-Tucker finite dimensional method. This approach is favored over closed-form solutions due to its flexibility in handling more general and complex models.

2. The Model

In the basic setting, the construction company sells houses directly to consumers. For a two-period model with demand high and low, the manufacturer must determine the house quantity and price floor before the resolution of demand. Assume the demand with uncertainty at first period ($t = 1$) is:

$$Q = aX - bP \tag{1}$$

X denotes the demand uncertainty that realizes at $t = 2$, and follows a binominal probability distribution as follows:

$$X = \begin{cases} X_H = Xe^{v\sqrt{t}}, & with \quad probability = \alpha \\ X_L = Xe^{-v\sqrt{t}}, & with \quad probability = 1 - \alpha \end{cases} \tag{2}$$

Along with house quantity Q, the construction company also determines the price floor $\underline{P}$ before the realization of market demand. If demand turns out to be the low-demand state ($X = X_L$), and flexible price is lower than price floor at $t = 2$, there are unsold quantities at the binding price floor, the salvage value per unit is s. With the assumptions given above, the profit maximization problem for the manufacturer can be written as:

$$\underset{Q,\underline{P}}{Max} \quad \pi_M = (-f_0 - f_1 Q)Q + m(\frac{a}{b}X_H - \frac{Q}{b})Q + u\underline{P}(aX_L - b\underline{P}) - us(Q - (aX_L - b\underline{P}))$$
$$s.t. \quad \frac{aX_H}{b} - \frac{Q}{b} \geq \underline{P} \geq \frac{aX_L}{b} - \frac{Q}{b} \tag{3}$$

where $TC = (f_0 + f_1 Q)Q$ is construction cost function.

The flexible price at high demand $aX_H/b - Q/b$ must be higher than or equal to price floor $\underline{P}$ otherwise there would be unsold goods even in the high-demand state. This would be economically unreasonable and sufficient conditions for profit maximization would not be met. If the price at low demand $aX_L/b - Q/b$ is higher than price floor $\underline{P}$, the price floor would not bind even in the low-demand state, making the price floor meaningless.

To obtain the optimal values for price floor $\underline{P}$ and quantity Q, this study uses a Kuhn-Tucker finite dimensional method to search maximum profit points. The provided image illustrates a 3D profit surface, demonstrating how profit varies with changes in quantity (Q) and price floor ($\underline{P}$). The study employs a Kuhn-Tucker finite dimensional method to locate maximum profit points. Figure 1 presents two perspectives of this profit surface. The left graph shows profit as a function of Q and $\underline{P}$, with $\underline{P}$ on the x-axis and Q on the y-axis, and profit on the z-axis. The right graph presents the same data but with Q on the x-axis and $\underline{P}$ on the y-axis. The red dots on both surfaces represent calculated profit points. The objective is to identify a set of $[Q, \underline{P}]$ that maximizes profits without binding. However, as solutions approach the subjective binding conditions, the study prioritizes solutions that offer the greatest profits along these boundaries, indicating a nuanced approach to optimization.

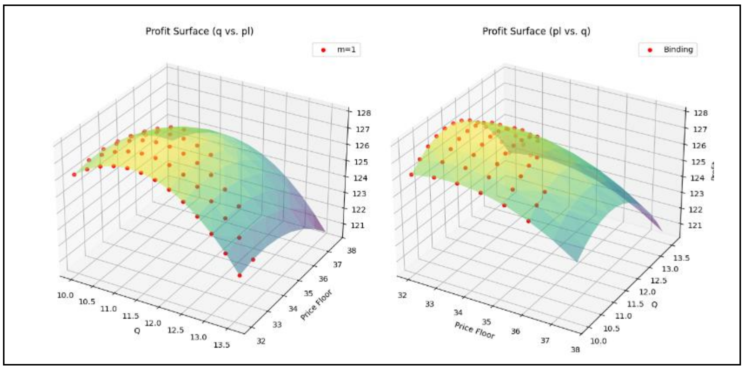

Figure 1. Quantity and price floor maximize the profit

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Figure 1 shows that profits correspond to the quantity and price floor from two different angles. We can find a set of $[Q, \underline{P}]$ that maximizes profits while not binding. As the solutions approach the subjective conditions of binding, we will pick solutions with the greatest profits along with boundaries.

3. Downward price rigidity

The model can show the relations between flexible pricing and price floor. In Figure 2.1, we can see flexible pricing at high demand and low demand, which are denoted by dotted lines. The price floor is represented by a solid line. Figure 2.1 shows their responses to construction costs f_0. When f_0 stays low, the price floor binds with high demand price, indicating the price sticks at high demand price even demand turns out to be low. As construction costs f_0 becomes higher, the distance between high demand price and price floor become wider, which is denoted by L_1. So there is no upward prcie rigidity. On the contrary, the theorectical price uncertainty is denoted by L_0. As f_0 gets higher, unsold house units become riskier, the company needs to lower down price at low demand state. High transaction costs, particularly taxes, impede homeowner mobility and shift activity towards the rental market, reducing the supply of properties for sale and contributing to price stickiness. Search frictions, inherent in housing markets, lead to price dispersion and stickiness as sellers rationally balance price with time-to-sell. Pervasive information asymmetry, where sellers often possess superior knowledge about neighborhood characteristics, also contributes to slower price discovery and adjustment.

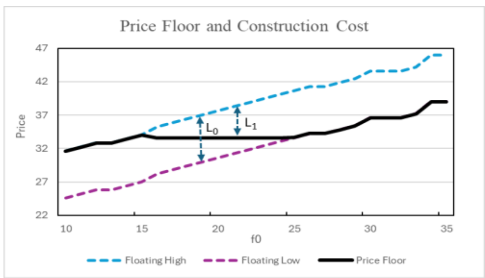

Figure 2.1 price floor and construction costs

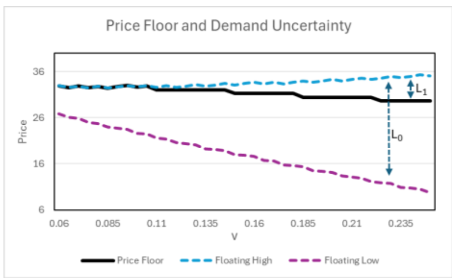

Figure 2.2 price floor and implicit variance

Suppose that demand turns out to be low and construction costs start to fall, traditional economic wisdom predicts that price adjustment will behave like L_0, while actual adjustment behaves like L_1. The price floor prevents deep price cuts and demonstrates a downward price rigidity. Figure 2.2 shows that price floor falls as uncertainty parameter increases, but the actual price adjustment (L_1) is much lower than that (L_0) in flexible pricing. A significant consequence of this rigidity is that the observed volatility of house prices is lower than the actual volatility of underlying demand, as the price floor effectively prevents prices from experiencing deep cuts. A key prediction of the price floor model is that downward price rigidity results in house price volatility that is *lower* than the volatility of actual underlying demand. This occurs because the price floor acts as a buffer, preventing prices from falling as much as they otherwise would during periods of slack demand. Empirical analysis of housing markets in the United Kingdom and the United States supports this prediction. Studies show that shocks in housing prices have a positively asymmetric effect on the conditional variance in the following period. Specifically, positive shocks in housing prices increase conditional variance more than corresponding negative shocks.[27] This finding is consistent with the hypothesis that downward rigidity prevents prices from appropriately adjusting downwards, thereby suppressing volatility during downturns. The discrepancy between observed price volatility and actual demand volatility is a crucial observable consequence of downward rigidity. The empirical finding of asymmetric volatility provides further robust support, indicating that prices are indeed more constrained on the downside, leading to less variance during market contractions compared to expansions. This implies that price signals in the housing market may not fully reflect underlying demand fluctuations, potentially misleading market participants and policymakers about the true state of the market and the severity of demand shocks.

4. Conclusions

This research employs an economic model to explain house price rigidity. Given the durable nature of housing, unsold units retain residual value, leading to the existence of an optimal price floor for profit maximization. During economic recessions, this binding price floor results in prices being less responsive to demand and cost shocks, demonstrating downward price rigidity. In conclusion, downward house price rigidity is a deeply ingrained characteristic of real estate markets, stemming from a complex interplay of rational firm strategies, human behavioral biases, and structural market imperfections. Its pervasive presence distorts price signals, impacts aggregate consumption, complicates monetary policy transmission, and fundamentally reshapes investment landscapes. Downward house price rigidity carries significant macroeconomic and policy implications, affecting aggregate consumption, the effectiveness of monetary policy, and broader economic stability. This study contributes to the literature by highlighting that prices may not accurately reflect true information, contrary to conventional wisdom. The price floor's distortion of the price mechanism necessitates increased attention to output contraction.

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