

Effect of Housing Supply Control Strategy

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Abstract:

High-cost threshold induces oligopoly for real estate market, which means a few powerful developers may easily control the supply of houses. On the other hand, land scarcity and regulation also induces the limited housing supply, therefore, housing supply control strategy may exist which can increase the developers' profit. While on demand side, speculative demand exists in housing market as property is not only consumption goods, but also an investment. Such demand is relatively vibrational while it is strongly affected by supply signal. In the paper, we analyze the profit change under supply control strategy and show that how property developers make control decision by introducing a mathematical model. The result suggests supply control strategy may achieve higher profit by stimulating the speculative demand if Control Interval is nonempty. Additionally, we also found that marginal return and marginal cost is not equal when developers facing the discrete real estate demand. VAR model is employed to test the dynamic relationship among housing supply, house price index and developers' profit in Hong Kong. During 1984 to 1997, housing supply was limited due to the Sino-British Joint Declaration; and we can see that supply control in the period significant bring up developers' profit.

Keywords:

Supply control strategy; Speculative demand; Marginal inequality;
Hong Kong real estate market

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Introduction

In this paper, we discuss the supply control strategy which is induced by land regulation and oligopolic housing market; and demonstrate the increased profit for developers under this control. The strategy relies on potential speculative demand which generally exists in housing market; and the major mechanism for such strategy is evoking the positive demand shift by giving negative supply signal. This positive demand signal will bring a higher equilibrium point in real estate market. However, as the supply shift is negative, the total profit change for housing developer remains uncertain. This paper actually derive a model to describe the profit change for developers; and it suggest that developers can limit the supply in a certain interval, which we call *Control Interval* to receive positive profit change.

The fundament of our research is the demand and supply in Neoclassical Economics. In real estate market, the demand and supply has its own characteristics which bring our research more meaningful. In demand side, houses, as goods needed for all the people, can be seemed as consumption; which means one reason for demand of housing comes form the basic need of our nature. On the other hand, housing price fluctuation is more stable than other derivates in financial market while real estate investment return is typically higher. Therefore, demand of housing also comes from the investment needs. Such investment needs normally increase in house price rising market, thus can be seemed as a general form of speculation. (Malpezzi and Wachter, 2002) We will call it speculative demand through out this paper.

On the supply side, housing development requires high threshold cost so that it induces a few powerful developers in this market, and they can easily control the housing supply. Furthermore, each developers has significant proportion of the market, hence the impact of each supply control decision can bring the positive shift to demand. Additionally, because of the scarcity, usage of land resource is normally

restricted by policy, environmental issue etc; and such regulation may raise the house price level. Actually, investor pay great attention to supply change in housing market, and the supply issue will affect their final decision. In this way, supply of houses becomes a signal for potential speculative demand. Generally, supply control strategy includes the subjective and objective situations, and both of them are possible to increase developers' profit.

The aim of developers focuses on the profit of housing development, therefore our study try to depict the profit of developer before and after the housing supply control strategy; and the whole analysis in this paper will also base on this profit change. As supply control has potential for higher profit and seems to be supported by characteristics of housing market, further study on such strategy is required. And this paper tries to discuss this phenomenon as a beginning of the research.

The structure for our paper will be run out as follow: firstly, we will review the previous researches on supply control and relative topic in this study. The fundamental assumptions for modeling will also be given in this part. Secondly, we will introduce our model under the assumptions and find out the *Control Interval* using mathematical way. For the third step, we depict the discrete demand function for housing developers, and point out that when doing optimization decision under this demand, marginal revenue and marginal cost may be unequal. After that, we use vector autoregressive (VAR) regression model to explore the dynamic relation among housing supply, house price and developers' profit. Especially, we focus on the period between 1984 and 1997, when supply of housing are controlled by Sino-British Joint Declaration; and find the significant negative relation between housing supply and developers' profit. Finally, we will make a conclusion for this paper.

Literature Review

Real estate developers often operate in oligopolistic environment in reality (Ong, et al, 2003). Because of high threshold for investment and great scarcity of land resource, real estate developers have to perform strong control in both land market and housing market. Wu and Li (2007) also points out that the market structure can cause the supply to be controlled by a few powerful developers that may manipulate the supply of houses. That is to say, only a few powerful developers hold a significant proportion of all the housing supply. Supply may has significant reduction and affect the housing market strongly if one developer hold the control strategy. Actually, oligopoly has been long emphasized in previous researches. Schwartz and Tourus (2003) construct a Herfindahl ratio to determine the effect of oligopolistic competition on real estate construction starts. Grenadier (2005) also used a special case of the option exercise game framework to explore a continuous-time Nash Equilibrium which bases on oligopolistic real estate market.

Furthermore, as the land resource is scarce, the usage of land always encounters regulation, such as environmental protection, transportation problem, policy restriction, etc. Such supply constraints are sometimes blamed for high housing price (Glaeser, et al, 2005). Therefore, supply control not only comes from subjective operation, but also from objective restriction.

Under Neoclassical Economic Framework, house price is determined by both supply and demand of the housing market. However, most of the studies consider demand-side variables such as tax, income and demographic variables (Poterba et al., 1991; Davidoff, 2006; Case and Mayer, 1996), while the studies on supply-side variables are much fewer. (Malpezzi, 1996) Whereas, oligopolistic real estate market and land use regulation means housing developers may control housing supply so that the influence of such strategy need to be studied. Previous researches on supply

constraint have covered several reasons such as land regulation, durable construction, etc. (Maclennan, 1982; Green, 1999; Quigley and Raphael, 2005); and they found out that these supply constraint has significant raising house price.

But for subjective purpose, as supply control may also increase the selling price of houses, the profit may become higher with supply control strategy. Some papers have revealed the strategies performed by real estate developers. Nourse, Roulac and Lundstrom (1993) mentioned that real estate operation decisions are consistent with enterprise's overall strategy. Ong, et al, (2003) also studied the pricing strategy using game theory. They concluded that such strategy appears to the best profit maximizing strategy. Thus, subjective supply control, as a possible strategy from housing developers, cannot be neglected. As both subjective and objective reasons have been emphasized, the study of supply control strategy and developers' profit is necessary.

Speculative demand is also a prevailing topic in real estate researches. Many researchers have observed that speculation in land or in real estate market is prime factor that drives house price cycle. (Atterhog, 1995; Feagin, 1982; Malpezzi & Wachter, 2002) Though the accurate definition for speculation has not been given or not yet been generally accepted, the major characteristics for speculative demand have been discussed in many papers. These include: short time horizon of investor (Titman 1985; Mayo and Shephard 2001); arbitrage (Lin and Vandell 2001); high vacancy rate (Struky, 1988); expectations are formed in some inaccurate way (Malpezzi & Wachter, 2002). Additionally, normal phenomenon for speculation is higher demand accompanies with higher house price which is contradict with neoclassical economics (Huang & Ge, 2008).

As the behavior for normal consumption and speculative demand share a completely different character toward house price change, we must separate them in our study on supply control. To be exactly, by giving negative supply change signal, speculators expect excessive demand in the future, therefore speculative demand increase. And

this increase induces the possible higher profit under supply control strategy.

Model Development

Housing demand is naturally divided into two groups: normal consumption demand and speculative demand. These two groups of customers have different behaviors towards house price. In oligopolistic market, price discrimination which means the practice of charging different price on different customers may be possible. Particularly, the existence of two clusters of demand satisfies the basic assumption of third degree price discrimination. However, the problem for applying third degree price discrimination is also obvious. Two groups of customers are included in only one real estate market so that developers can merely give out one set of information (one asking price and one supply quantitative). The driven forces behind two groups of customers are their behavior characters. That is to say, the different reflections of supply signal and price change contribute to the change of developers profit under supply control strategy.

To simplify our model, we provide the following assumptions:

Assumptions I: Normal consumption demand exists before the supply control strategy; and the speculative demand is 0 if without supply control information.⁴ When supply of houses was control to a sufficiently low level, speculative demand will be aroused.

Assumption II: Normal consumption demand will not be affected by supply control

⁴ Supply of houses is inelastic due to time-consuming construction and land scarcity etc. Therefore, in reality, speculative demand also exists before supply control strategy. As speculators looking forward to profit from resale of houses in short term, it's reasonable to assume such demand is zero if supply of housing is unlimited, which also imply elastic supply. The purpose for such assumption is to simplify our model; and even with part of speculative demand, the conclusion is the same as ours.

strategy. That means the demand curve of this customers group will not shift after the supply control.⁵

Before the supply control strategy, only normal consumption demand exists in real estate market. Therefore, the demand curve faced by housing developers would be:

$$Q_{ncd} = a_1 - b_1 P \quad \dots\dots\dots (1)$$

Here, Q_{ncd} refers to housing demand; P is house price; a_1 and b_1 are positive constant.

Using inverse demand function, house price and demand and the following relation:

$$P = \frac{a_1}{b_1} - \frac{1}{b_1} Q_{ncd} \quad \dots\dots\dots (2)$$

Therefore, the total revenue for housing developers would be:

$$TR = \frac{a_1}{b_1} Q_{ncd} - \frac{1}{b_1} Q_{ncd}^2 \quad \dots\dots\dots (3)$$

And the marginal revenue is: $MR = \frac{a_1}{b_1} - \frac{2}{b_1} Q_{ncd}$ (4)

Additionally, suppose the cost function for housing developers is:

$$TC = FC + c \times Q \quad \dots\dots\dots (5)^6$$

With marginal cost: $MC = c$ (6)

In Equation (5), FC is the fixed cost for developers such as management fee, land price etc; c is variable cost for additional houses. Both of them are constant.

With market clearance, the profit function for housing developers without supply control strategy will be as following:

⁵ The normal consumption demand basic on the basic need of customers so that we assume it to be stable. In reality, such demand will also be affected as the expectation of supply shortage. With this assumption, we separate the expectation change for basic need and include it in speculative demand. That means, to some extent, normal consumption demand has speculative character; and we separate it to simplify our model.

⁶ Because the construction cost for one additional house (marginal cost) depends on exogenous variables, such as labor wage, material cost etc. We take it as constant to simplify the model.

$$\Pi_1 = \left(\frac{a_1}{b_1} Q_{ncd} - \frac{1}{b_1} Q_{ncd}^2 \right) - (FC + c \times Q_{ncd}) \dots\dots\dots (7)$$

Because housing developers supply houses at the point of profit optimization, which also implies $MR = MC$, we can obtain the market conditions without supply control strategy. In this situation, volume for housing transaction will be:

$$Q_{ncd}^* = \frac{a_1}{2} - \frac{c^* b_1}{2} \dots\dots\dots (8)$$

And the house price will be at:

$$P = \frac{a_1}{b_1} - \frac{1}{b_1} \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right) \dots\dots\dots (9)$$

The total profit for housing developers without supply control strategy would finally be:

$$\Pi_1^* = \frac{a_1}{b_1} \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right) - \frac{1}{b_1} \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right)^2 - FC - c \times \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right) \dots\dots\dots (10)$$

This is the standard profit which will be compared with profit under supply control strategy. If the new profit is higher than Π_1^* under strategy, we call the strategy is available.

Now, we consider the supply control strategy is applied by housing developers. In order to attract speculative demand, the supply was limited at a fairly low level. We assume that the speculative demand will be stir up when supply of houses falls to a sufficiently low level, Q_{cont} . And it's obvious that $Q_{cont} < Q_{ncd}^*$, because speculators can expect the shortage of houses supply and the rise of house price. The profit of speculators comes from house price inequality: $P(Q_{cont}) > P(Q_{ncd}^*)$. Because speculation has risk, the relation is strict inequality as risk premium exists; and this comes out to be the reason for strict inequality in $Q_{cont} < Q_{ncd}^*$.

We assume that the aroused speculative demand of houses can be described by the

following demand function:

$$Q_{sd} = a_2 - b_2P \dots\dots\dots (11)$$

With assumption II above, the normal consumption demand will not be affected by supply control strategy. Hence, the total demand in housing market comes out to be:

$$Q = Q_{ncd} + Q_{sd} = (a_1 + a_2) - (b_1 + b_2)P \dots\dots\dots (12)$$

Take the inverse demand function and multiple the quantitative of houses, new revenue for developers would then be:

$$TR = \frac{a_1 + a_2}{b_1 + b_2} Q - \frac{Q^2}{b_1 + b_2} \dots\dots\dots (13)$$

The cost function for housing developers remains the same as Equation (5) and the marginal cost is still Equation (6), as cost function will not shift its position with supply decision. Thus, the new profit function for housing developers will be:

$$\Pi_2 = \left(\frac{a_1 + a_2}{b_1 + b_2} Q - \frac{Q^2}{b_1 + b_2} \right) - (FC + c \times Q) \dots\dots\dots (14)$$

As the new housing demand shift upward, the optimization for above profit will lead to a higher supply of houses. The solution contradicts with supply control strategy. Thus new supply constraint, $Q \leq Q_{cont}$, is provided as developers applying the strategy. In sum, the availability of supply control strategy relies on the following inequality system:

$$\left\{ \begin{array}{l} \Pi_2 = \left(\frac{a_1 + a_2}{b_1 + b_2} Q - \frac{Q^2}{b_1 + b_2} \right) - (FC + c \times Q) > \Pi_1^* \dots\dots\dots(15) \\ 0 \leq Q \leq Q_{cont} \dots\dots\dots(16) \end{array} \right.$$

In Inequality (15), $\Pi_1^* = \frac{a_1}{b_1} \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right) - \frac{1}{b_1} \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right)^2 - FC - c \times \left(\frac{a_1}{2} - \frac{c^* b_1}{2} \right)$

which is the maximum profit achieved without supply control strategy. And Inequality (16) is the supply constraint under strategy. If this inequality system has positive solution, we can claim that supply control strategy is available.

Inequality (15) has quadratic form; and we know that it has solution merely when it satisfies the following conditions:

$$\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC) \geq 0$$

Since a_i , b_i , c , Π_1^* and FC are positive, this conditions can be automatically satisfied; the only thing need to be concerned is whether the solution is in the interval $[0, Q_{cont}]$. Therefore, the **condition for supply control strategy** is:

$$\left[\frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) - \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}}, \frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) + \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}} \right] \cap [0, Q_{cont}] \neq \emptyset \dots\dots\dots (17)$$

$$\text{And } \left[\frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) - \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}}, \frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) + \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}} \right] \cap [0, Q_{cont}]$$

is the **Control Interval** for this strategy.

Condition for supply control strategy, which is described by formula (17) would only be rejected if:

$$\frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) + \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}} < 0 \quad \text{or} \quad \frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) - \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}} > Q_{cont}$$

Therefore, this condition can also be expressed as

$$\frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) + \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}} \geq 0 \quad \text{and} \quad \frac{\left(c - \frac{a_1 + a_2}{b_1 + b_2}\right) - \sqrt{\left(\frac{a_1 + a_2}{b_1 + b_2} - c\right)^2 + \frac{4}{b_1 + b_2}(\Pi_1^* + FC)}}{\frac{2}{b_1 + b_2}} \leq Q_{cont}$$

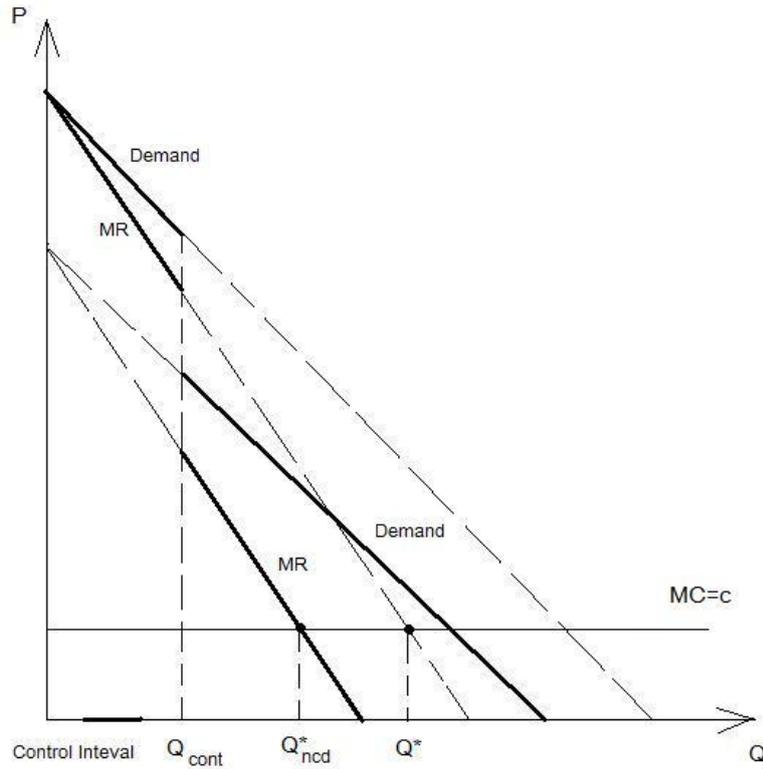
Marginal Inequality for Optimization

Discussion above shows that supply control strategy can arouse speculative demand by providing supply information. So, from the view of housing developers, the demand function they are facing is not continuous. When supply of houses be restricted below Q_{cont} , housing demand will be stirred up by adding speculative demand. The discrete demand induces an interesting phenomenon that marginal cost and marginal revenue is unequal when developers maximize their profit; and Figure 1 depict such inequality.

In Figure, we can see that the demand function and marginal revenue (the blacked real lines) in real estate market was separated into two parts. Without supply control strategy, the optimum point for developers is Q_{ncd}^* , and the optimum point; and for adding speculative demand, optimum point changes to Q^* . $MC = c$ is the marginal cost for housing development. At both Q_{ncd}^* and Q^* , marginal equality $MC = MR$ is satisfied.

But in Figure 1, Q^* is larger than Q_{ncd}^* , which contradicts with supply constraint, Inequality (16). Therefore, it's not achievable. Instead, we found the Control Interval (blacked on Q-axis) within which profit is higher than that at Q_{ncd}^* . Hence, the optimum point for housing developers should be that in Control Interval.

Figure 1: Marginal Inequality



However, whether the assumption, Q^* is larger than Q_{ncd}^* , is possible may be casted doubt on. Thus, we prove that if supply control can completely raise the demand, Q^* is strictly larger than Q_{ncd}^* by the following proof.

Assumption (**Completely Raised Demand**): after applying supply control, new demand of houses merely shift upward in first quadrant (include Q-axis and P-axis).

That means in Figure 1, $P_{new} = \frac{a_1 + a_2}{b_1 + b_2} - \frac{1}{b_1 + b_2}Q \geq P_{old} = \frac{a_1}{b_1} - \frac{1}{b_1}Q \geq 0$ for

$\forall Q \geq 0$. Obviously, it's equivalent to say that

$$Q = Q_{ncd} + Q_{sd} = (a_1 + a_2) - (b_1 + b_2)P \geq Q_{ncd} = a_1 - b_1P \geq 0, \text{ for } \forall P \geq 0.^7$$

⁷ The inequality ≥ 0 uses to restrict our discussion on non-negative house price and supply.

From the statement $Q_{ncd} \leq Q_{ncd} + Q_{sd}$ above, we can see that this assumption means the aroused speculative demand is always non-negative for any house price level. With this assumption, we can obtain that Q^* is larger than Q_{ncd}^* in Figure 1.

Proof: Since the marginal revenue function without supply control was given as Equation (4), which is $MR_1 = \frac{a_1}{b_1} - \frac{2}{b_1}Q$. At the meanwhile, the marginal revenue function under supply control is $MR_2 = \frac{a_1 + a_2}{b_1 + b_2} - \frac{2}{b_1 + b_2}Q$, which can be obtained by differentiate Equation (13). To prove that Q^* is larger than Q_{ncd}^* , sufficient to show $MR_2 > MR_1 \geq 0$ for $\forall Q \geq 0$.

Because MR_2 and MR_1 are straight line, if we can show that MR_2 's interception at Q-axis and P-axis is not lower than those of MR_1 , it's enough. Firstly, let $Q = 0$, we have $MR_2 = \frac{a_1 + a_2}{b_1 + b_2} \geq MR_1 = \frac{a_1}{b_1} \geq 0$ by assumption of Completely Raising Demand.⁸ Secondly, we can find out that when $MR_2 = MR_1 = 0$, $Q(MR_2) = (a_1 + a_2)/2 \geq Q(MR_1) = a_1/2$. Therefore, we have $MR_2 > MR_1 \geq 0$ for $\forall Q \geq 0$. □

Now, we can conclude that optimum point Q^* is larger than Q_{ncd}^* under

Draw a sectional line perpendicular to Q-axis or P axis at first quadrant, interception with shifted demand curve is not lower than that with original demand curve.

⁸ Because $P_{new} = \frac{a_1 + a_2}{b_1 + b_2} - \frac{1}{b_1 + b_2}Q \geq P_{old} = \frac{a_1}{b_1} - \frac{1}{b_1}Q \geq 0$ for $\forall Q \geq 0$, we take $Q = 0$ to obtain

$$MR_2 = \frac{a_1 + a_2}{b_1 + b_2} \geq MR_1 = \frac{a_1}{b_1} \geq 0.$$

Completely Raised Demand. However, Q^* is not achievable under supply control strategy, and instead, the global profit maximum points fall into Control Interval where, marginal cost is not equal marginal revenue. Hence, when real estate developers optimizing their profit facing the discrete demand function, marginal inequality occurs which means $MR \neq MC$. And the reason for this phenomenon is developers use supply control information to arouse speculative demand.

Empirical Study for Supply Control Strategy

The mechanism of supply control strategy is that housing developers provide a supply control signal, for both subjective and objective reasons, to arouse speculative demand. Then the higher demand, accompanied with shortage of supply, brings house price to a higher level, which finally offset the profit reduction caused by transaction volume. This mechanism implies some possible phenomenon, which provides us the method to observe and test whether supply control strategy is possible. If supply control strategy works, we should observe that reduction of supply will induce the increase of house price. Therefore, supply of houses and house price would change in different direction in such period. What's more? As supply control is applied for higher profit, we should also expect the negative relationship between housing supply and developers' profit within the control period.

The housing market data of Hong Kong were collected from Census and Statistics Department of Hong Kong for empirical study. The number of newly completed private residential buildings provides the information of houses offered by real estate developers; therefore we choose it as housing supply data. Additionally, House price index (benchmark at 1999) was used to represent house price. For the developers' profit, we employ the Gross Domestic Capital Value (at current market price) from private building and construction sector to depict it. In fact, the original record for real

estate developers' margin was combined in this capital value after 2002; and this value comes from the added value of developers' product. Therefore, it's reasonable to use it as developers' profit. All of them are annual data with range from year 1979 to 2008.

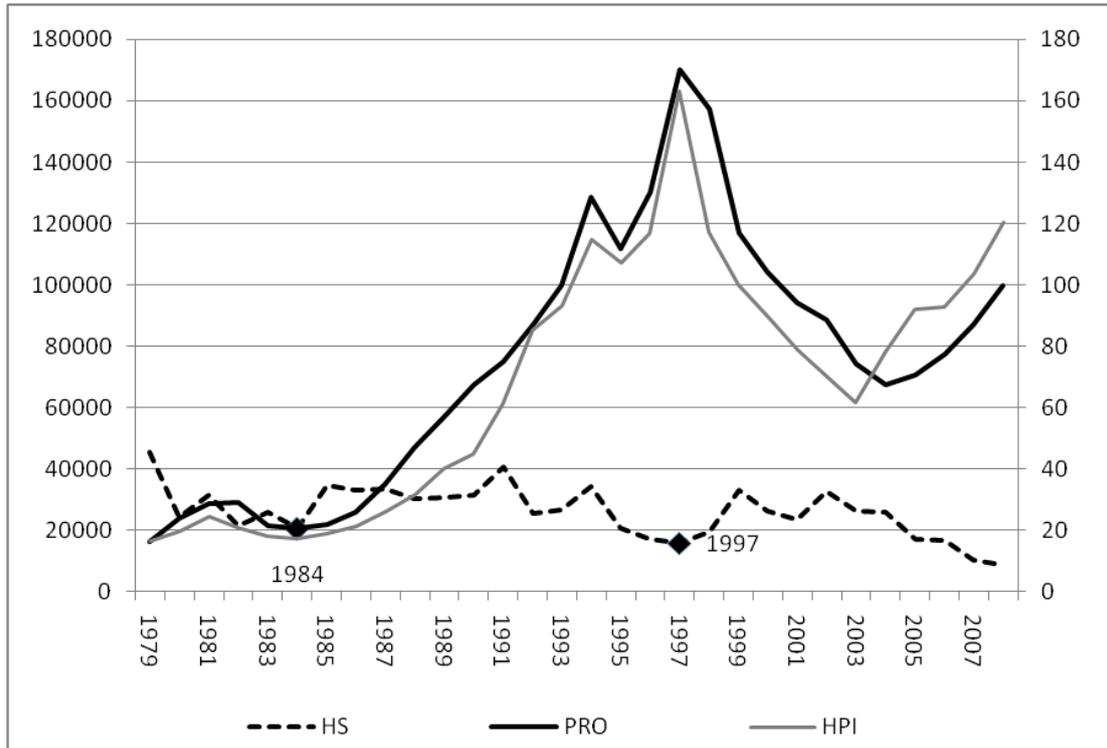
Descriptive statistics for housing supply, house price index and developers' profit are showed in Table 1.

Table 1: Descriptive statistics for variables

Variables	Housing Supply	House Price Index	Estimated Profit
Mean	26166.90	68.18800	74509.00
Median	26155.00	73.96000	74816.00
Maximum	45322.00	163.1300	170104.0
Minimum	877600	16.50000	16204.00
Std. Dev	8403.167	40.94304	42326.38
Skewness	-0.008791	0.231396	0.368627
Kurtosis	2.789688	2.055324	2.389444
Observation	30	30	30

Note: Housing supply is measured by number of newly completed private residential buildings. House price index with benchmark at 1999. Real estate developers' profit measured by Gross Domestic Capital Value (at current market price) from private building and construction sector. All of them are annual data from 1979 to 2009.

Figure 2: housing market data in Hong Kong



*: Data source: Census and Statistics Department of Hong Kong

Actually, from the data of Hong Kong, we can observe the expected phenomenon, which are showed in Figure 2 above. In the Figure, the broken line depicts the number of newly completed private residential building, which we use for housing supply data. The grey real line is the house price index while the black real line is the developers' profit. The Sino-British Joint Declaration restricts the land supply from 1984 to 1997. During this housing supply control period, housing supply decreased slowly until it reach the bottom at 1997. To the contrary, the movement of house price and developers' profit depart from the trend of housing supply. Both of them increased dramatically. This is consistent with the phenomenon of supply control strategy. After 1997, the restriction from Joint Declaration released and the house price index and profit for the developers dropped down simultaneously. We know that speculative demand suffered from great impact of the financial crisis at 1997, and, therefore, the dramatic decrease, to some extent, implies the influence of previous supply control.

To provide an accurate test, we employ a vector autoregressive (VAR) regression

model to examine the relationship among housing supply (HS), house price index (HPI) and estimated profit (PRO). Actually, VAR model was widely used to explore the dynamic relationship among variables. (Fisher, et al., 2009; Deng, et al., 2009) In the simplest form, VAR model composed of a system of regressions where a set of dependent variables are expressed in linear form. It can be represented as:

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_k Y_{t-k} + e_t$$

Where Y_t is a vector of variables, μ is a vector of intercepts, $\Phi_1, \Phi_2, \dots, \Phi_k$ are parameters with all eigenvalues of Φ having moduli less than 1 so that VAR is stationary. Because we want to explore the relation among HS, HPI and PRO, all of them will be included in VAR model. Additionally, Maximum Likelihood Estimation is used to obtain Φ .

Another problem for VAR model is choosing the time-lag periods k . Because housing developers use supply control information to arouse speculative demand, and such information should be transferred immediately to make the strategy sufficient, choosing $k = 1$ seems reasonable as we use annual data. Moreover, using AICc as a criterion for k selection, we also obtain that $k = 1$ provides the best fitted model. AICc is Akaike Information Criterion (AIC) with the second order correction for small sample sizes.

$$AICc = AIC + \frac{2k(k+1)}{n-k-1}$$

Here, k denotes the number of model parameter, n denotes the sample size.

The reason we choose AICc here is that the time period for supply control is merely 14 years; and the sample size of data collected is relatively small. Therefore, we need to use AICc as an adjustment. Burnham and Anderson (2004) has even mentioned that

AICc should be employed regardless of sample size because when n gets large, AICc will converge to AIC.

Since the supply control affects from 1984 to 1997, we add a dummy variable (D) to the above VAR model to mark this period. During the supply control period, the dummy variable is equal to 1, while at other times it becomes 0. That is to say, the VAR model becomes the following one:

$$Y_t = \mu + \Phi_1 Y_{t-1} + D \cdot \Phi_2 Y_{t-1} + e_t$$

$$\text{With: } D = \begin{cases} 1 & t \in [1984, 1997] \\ 0 & t \notin [1984, 1997] \end{cases}$$

Concentrating on how supply changes would affect house prices and profits, we are interested in the coefficients of HS where the dependent variables are HPI and PRO. To be more accurate, the coefficient matrix Φ_2 collects the information within the supply control period. If the supply control strategy is available, we should expect the coefficient of HS in Φ_2 to be negative. Therefore, the null hypothesis (H_0^1) would be:

$$H_0^1: \beta'_{HS} > 0 \quad (\beta'_{HS} \text{ is the coefficient for HS in } \Phi_2)$$

If the null hypothesis is rejected in the model, the supply control strategy was verified. Since when we run the regression within the supply control period where $D=1$, the result directly shows the coefficients of HS which combine the coefficients in Φ_1 and Φ_2 .

Therefore, the null hypothesis (H_0^1) changes to be:

$$H_0^1: \beta_{HS,1} > \beta_{HS,0}$$

Where $\beta_{HS,1}$ is the coefficient for HS when D=1 and $\beta_{HS,0}$ is the coefficient for HS when D=0.

The result of Vector Autoregressive Regression Model is presented in Table 2. and from this table, we can observe that the null hypothesis are rejected. Thus we can conclude that supply control strategy is available.

Table 2: Estimation of VAR model

Variables	<i>D</i> = 1 model (from 1984 to 1997)			<i>D</i> = 0 model (from 1979 to 2008)		
	PRO	HPI	HS	PRO	HPI	HS
Constant	29765.60 (1.516)*	16.868 (0.88676)	28923.00 (2.973)***	5846.227 (0.397)	9.553 (0.570)	28665.01 (5.542)***
<i>PRO</i> _{<i>t</i>-1}	1.274 (2.147)**	0.001 (1.299)	0.249 (0.848)	0.463 (1.972)**	0.000 (-0.928)	0.391 (4.736)***
<i>HPI</i> _{<i>t</i>-1}	-203.593 (-0.326)	0.355 (1.169)	-361.821 (-1.168)	503.754 (1.899)**	1.176 (3.892)***	-484.6005 (-5.198)***
<i>HS</i> _{<i>t</i>-1}	-0.889 (-1.436)*	-0.001 (-1.112)	0.117 (0.382)	0.118 (0.274)	0.000 (0.047)	0.009 (0.057)
Adj. R ²	0.924	0.928	0.429	0.882	0.838	0.576
F-statistic	53.399	56.568	2.503	70.609	49.244	13.670
AICc	26.433	12.554	25.028	23.957	10.214	21.678

Notes: t statistics in parentheses; ***, ** and * represent 5%, 10%, 20% significant levels, respectively.

Focus of the impact of supply on house price and developers' profit, we pay attention to the first two column of both models. Overall, *D* = 1 model is able to explain 92.4% of the variation in PRO and 92.8% of variation in HPI. On the other hand,

$D = 0$ model is able to explain 88.2% of the variation in PRO and 83.8% of variation in HPI.

Additionally, to emphasize the availability of supply control strategy, we concentrate on the coefficients of HS and the significant statistics in estimated equation for PRO. As it's showed in Table 2 above, $\beta_{HS,1} = -0.889$ while $\beta_{HS,0} = 0.118$. This result rejects the null hypothesis so that it shows the supply control strategy had successfully raise the house price during 1984 to 1997. Additionally, t-statistics shows that using HS to explain PRO in supply control period is significant while it's insignificant to doing so at other time. This also supports the impact of supply control to developers' profit.

Actually, within the Neo-classical framework, supply and price level should be negative relative because decrease of supply will induce the shortage in goods market. However, in $D = 0$ model, the positive coefficient of HS in equations for HPI and PRO contradict the neo-classical framework; and supply impact is insignificant as t-statistics showed. It means that when supply control strategy was not applied, developers had not fully explored the housing demand to achieve excessive profit.

Summary and Conclusion

Neoclassical Economics suggests that house price analysis can base on housing demand and housing supply. On supply side, real estate market has oligopolistic structure so that a few powerful housing developers can manipulate market supply easily. Supply reduction from one developer may have significant impact on the whole market. Also, land use regulation provides objective reasons for supply restriction. On demand side, houses are taken not only as consumption, but also a kind of investment. Speculative demand, which invests in short time horizon, exists; and supply control may arouse such demand as expectation of house price growth. Therefore, housing developers may apply supply control strategy to push the house

price rise and increase their profit.

In this paper, we explore the mechanism of supply control strategy and set up a model to explain it. Profit is the target variables in our model and developers apply such strategy in order for higher profit. Because when supply control to a relatively low level, speculative demand will be stirred up, therefore, the demand function in real estate market is discrete function. Optimizing the profit under supply control strategy, housing developers should find the solution in inequality system (15) and (16). The supply control strategy is available only Control Interval (17) is not empty.

Additionally, under the assumption of Completely Raised Demand, the global optimum point on total demand curve ($Q = Q_{ncd} + Q_{sd}$) is not achievable as it contradict supply control. Therefore, when facing the discrete real estate demand function, the point that developers maximizing their profit has marginal inequality. That is to say, $MR \neq MC$ is not satisfied.

Finally, we use the data of Hong Kong (from 1979 to 2008) to verify supply control strategy. Particularly, we focus on the period from 1984 to 1997 when land supply is restricted by Sino-British Joint Declaration. Within this period, supply control strategy was applied and we can see the supply reduction induced the house price increase; and the negative relationship between housing supply and developers' profit. Vector autoregressive (VAR) regression model was employed to examine the dynamic relationship among housing supply (HS), house price index (HPI) and estimated profit (PRO). The null hypothesis for supply control strategy is the positive coefficients of HS in Φ_2 on HPI and PRO equation when $D = 1$. The estimated result rejects the null hypothesis, therefore supports the availability of supply control strategy.

Actually, the supply control strategy is not limited in real estate market. It can be extended to other market that speculative demand may exist. Markets for limited

version of products, such as CDs, concert tickets, are suitable for applying this analysis. Moreover, we assume the speculative demand which aroused by supply signal is discrete. That is to say when supply is restricted in a certain level, the fixed speculative demand is added. This assumption may be released to continuous so that when supply control continues, further speculative demand may be added. Therefore additional works are required for the study on supply control.

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