# Durable Goods Oligopoly with Time Variant Cost - in the Tokyo Condominium Market

Migiwa Tanaka

Johns Hopkins University

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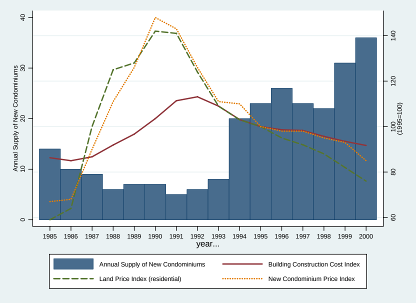
# Motivation - Historical Data

- Key variables in the Tokyo Condominium Market 1985-2000




- Annual condominium production has been around 7.9 thousand units between 1985-1993.
- It increased to 20.2 thousands in 1994 and maintains upward trend since then.
- The new condominium price index shows annual growth of 17% between 1985-1990. It has depreciated at 5.2% on average since 1991 after the burst of asset price bubble.
- Land price index and new condominium index are highly correlated over time.

# Motivation- Historical Data (cont.)

- It suggests that the movements of outputs and prices are largely driven by land price.
- It is reasonable as the largest factor of production of the condominium in terms of value is the land.
- But there is difference in the speed of deflation between land prices and condominium prices in 1990s.
- Does it suggest the imperfect competition in the primary market of condominium?
- Or is the gap explained by the appreciation of the construction cost relative to the land cost for the production of condominiums?

# Motivation-Existing Literature

- The limitation on the market power of producers(sellers) are extensively studied in I.O. literature since Coase(1972).
  - Intertemporal substitutions/rational expectations $\Rightarrow$ Time inconsistency problem
  - Contemporaneous substitutions through the secondary market.
- The secondary market may alleviate the harm of durability to the market power. [Carlton & Gertner(1989),Esteban & Shum (2006)]
  - Owners can resale the durable goods in the secondary market.
  - Producers may affect the resale value of the product by controlling future stock in the secondary market.
  - Whether she wants to increase or decrease the production depends on trade off that she faces in oligopoly market.

# Motivation-Existing Literature (cont.)

- The literature in housing economics usually assumes competitive primary market because:
  - it is claimed that home builders cannot have power given the large volume of existing stock.
  - Rosenthal(1999) showed empirically that the efficiency market hypothesis holds in the market of the single-family house in Vancouver.

Those analysis are based on the presumption that consumers do not distinguish the difference among the newly built houses and old (used) houses.

# Approach

In order to identify the degree of imperfect competition:

- The behaviors of durable goods producers and consumers are modeled and incorporated with important features of the Tokyo condominium market, namely time variant component of cost and exogenously evolving fringe competitors.
- The structural parameters of proposed model are estimated.
- The markup of a typical firm is recovered.

Furthermore, with the estimated model and simulations

- the difference in response of firms in the deflationary period and inflationary period in terms of land cost is investigated.

# Findings

- The markups are very small under estimated parameter value, suggesting the weak evidence of market power in the Tokyo condominium market.
- The equilibrium production policy of firms shows asymmetric response to the environment in the deflationary and inflationary phase.

# Outline

- Market Description
- Model
- Estimation
  - Data
  - Three-Step Estimation
- Estimation Results
- Conclusion

# Definitions of the Market and the Product

- The condominium is a multi-unit housing that consists of 5 units or more, has 3 stories or more with a steel-reinforced concrete structure.
- The market under study is the central districts within Tokyo metropolitan area.

| | Population | Households | Size($km^2$) | Size($mile^2$) | (year) |
|---|---|---|---|---|---|
| Tokyo (central districts) | 7.9 million | 3.5 million | 621 | 240 | 2001 |
| NYC | 8.1 million | 3.0 million | 785 | 303 | 2004 |
| Baltimore City | .66 million | 0.3 million | 210 | 81 | 2004 |

- As of 2001, more than half of households who purchase new housing choose condominiums over single detached house. This ratio has been about 45% on average throughout the 1990s.
- There are 2.2 million housing stock owned by individual households. About 20% of them are condominiums.

# Definitions of the Market and the Product (cont.)

- The statutory useful life of a condominium unit is 47 years in the tax law. However, condominiums generally requires either large scale repair or the complete replacement in 25 to 30 years.
- Duration of the construction is on average 15 months. The average time between completion of the building and sales is 6 month. In the sample, about 10 % of all units are sold before construction ends.

# Industry

- The supply of the new condominium usually involves two types of firms: the developers and the construction companies.
- A developer acquires land, plan the development projects and order the constructions to the construction firms.
- In some cases, the developer and construction company are either vertically integrated.
- In this study, the firms are assumed to produce the condominium units and sell them directly to consumers.
- Out of all condominiums supplied, we consider condominiums excluding studios.

# Industry (cont.)

# Industry (cont.)

- The number of firms has been under 75 till 1993 but it increased to 166 in 1994, when the supply spike was observed.
- The number of active firms remaind around 190 throughout the decade.
- The five-firm concentration ratio has been 0.31 on average.
- Out of all active firms, there are about 20-50 firms that participated only once in each year. They account for 23% of active firms on average.

- It indicated that the price is not significantly different from large firms.
- It supports the assumption that those small firms are price takers.

# Environment -Basic Setup

- Condominiums are durable and lasts in the market for 2 years after the production.
- It physically depreciates at the rate $1-\delta$.
- The goods are differentiated by the vintage but homogenous within the vintage.
- There are $J$ firms in the market and they are indexed by $j$.
- A firm $j$ produces $q_{jt}$.
- Common discount factor for both consumers and producers is $\beta$.

# Environment -Fringe Competitors and Stock

- Fringe competitors collectively produces $x_t$. It is assumed to evolve with random walk process:

$$x_t = x_{t-1} + \xi_t \tag{1}$$

where $\xi_t \sim N(0, \sigma_\xi^2)$.

- The stock of condominiums with age 1 at time $t$ is given by:

$$s_t = \delta \left( \sum_{j=1}^{J} q_{j,t-1} + x_{t-1} \right). \tag{2}$$

# Environment -Cost Function

- Firm $j$ incurs cost to produce $q_{j\tau}$ according to quadratic cost function

$$C(q_{j\tau}^0, c_\tau) = (\overline{c_1} + \widetilde{c}_\tau)q_{j\tau} + \overline{c}_2 q_{j\tau}^2, \tag{3}$$

where

  - $\overline{c_1}$ and $\overline{c_2}$ are constant. while
  - $\widetilde{c}_\tau$ is stochastic following $AR(1)$ process to capture the macro shock to the market:

$$\widetilde{c}_{\tau+1} = \rho\widetilde{c}_\tau + \eta_{t+1}, \tag{4}$$

where $\rho \in (-1, 1)$ and $\eta_t \sim N(0, \sigma_\eta^2)$.

# Environment -Law of Motion

$$\begin{bmatrix} s_{t+1} \\ x_{t+1} \\ \widetilde{c}_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & \delta & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \rho \end{bmatrix} \begin{bmatrix} s_t \\ x_t \\ \widetilde{c}_t \end{bmatrix} + \begin{bmatrix} \delta & \dots & \delta \\ 0 & \dots & 0 \\ 0 & \dots & 0 \end{bmatrix} \vec{q}_t + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \eta_{t+1} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \xi_{t+1}$$

For convenience of notation, the vector of state variable is denoted as $\vec{S}_t = [s_t \ x_t \ \widetilde{c}_t]'$.

# The Consumers

The demand side is modeled in the multinomial logit framework.

- There are $M$ households in the market and they are infinitely lived.
- Each household purchases at most a condominium unit.
- The choice is among new condominium, 1 year old condominium and outside alternative.
- The owner of new condominium can sell the unit in the secondary market after a year.
- The owner of 1 year old condominium will receive terminal value ($\overline{p}$) from the scrappage market after a year.
- There is no transaction cost.
- Goods are indexed by $d$, the vintage of product.
- $d = n$ denotes outside alternative.

With those assumptions, the consumers dynamic decision can expressed by the maximization of flow utility gain from owning the unit for a year.
Let denote utility gain from owning age $d$ unit for a year at time $t$ by $UG_{it}(d)$

$$UG_{it}(d) = \begin{cases} g(d) - \alpha ECC_t^d + e_{it}^d & \text{if } d = 0, 1 \\ e_{it}^d & \text{if } d = n, \end{cases}$$

where

- $g(d) =$ Quality level of vintage $d$.
- $ECC_t^d$ =expected capital cost of owning age $d$ unit for a year at time $t$ and defined by

$$ECC_t^d = \begin{cases} p_t^d - \beta p_{t+1}^{d+1} & \text{if } d = 0, \\ p_t^d - \beta \overline{p} & \text{if } d = 1, \end{cases}$$

- $\overline{p} =$ the terminal/scrappage value of the condominium when it reaches age 2 in period $t+1$.
- $e_{it}^d =$ Consumer heterogeneity and assumed to be iid type I extreme value distribution across individual, time and vintage.

By integrating consumer heterogeneity term $e_{it}^d$, the market share for each product $d$ is obtained.

$$\mu_t^d = \begin{cases} \dfrac{\exp\left(g(d) - \alpha ECC_t^d\right)}{1 + \sum\limits_{d'=0}^{2} \exp\left(g(d) - \alpha ECC_t^{d'}\right)} & \text{for } d = 0, 1 \\ \dfrac{1}{1 + \sum\limits_{d'=0}^{2} \exp\left(g(d) - \alpha ECC_t^{d'}\right)} & \text{for } d = n\ . \end{cases} \tag{5}$$

With the inversion technique of Berry(1994), we can derive the following expression:

$$\begin{aligned} \ln \mu_t^d - \ln \mu_t^n &= g(d) - \alpha ECC_t^d, & (6) \\ &= g(d) - \alpha p_t^d + \alpha\beta p_{t+1}^{d+1}, & (7) \end{aligned}$$

# Derivation of Inverse Demand Function

Arranging market share equations yields

$$
\begin{aligned}
p_t^0 &= \frac{1}{\alpha}\left[\sum_{d=0}^{1} \beta^d (\ln \mu_{t+d}^n - \ln \mu_{t+d}^d + g(d))\right] + \beta^2 \overline{p}, && (8)\\
&= P^0(s_t, x_t, \vec{q}_t, \vec{q}_{t+1}). && (9)
\end{aligned}
$$

- The firms have infinite life and maximizes PDV of profit stream.
- The solution concept is symmetric Markov Perfect Equilibrium.
- The time inconsistent solutions are not considered.

A firm $j$'s problem is then given by

$$\max_{q_{jt}^0} \sum_{\tau=t}^{\infty} \beta^{\tau-t} E_t \left[ p_{j\tau}^0 q_{j\tau} - C(q_{j\tau}, \widetilde{c}_\tau) \right], \tag{10}$$

subject to the law of motion and

$$q_{jt} = h_j(\vec{S}_t) and \tag{11}$$

$$q_{jt} \leq M - s_t - x_t - \sum_{j' \neq j} q_{j't}, \tag{12}$$

$$given q_{j't} = h_{j'}(\vec{S}_t),\ j' = 1, 2, ...j-1, j+1, ...J, \tag{13}$$

where

- $h_l(\cdot)$ is stationary policy function for firm $l$
- With constraint (12), there is no oversupply.

The firm's problem can be reformulated into the recursive form.

$$V_j(\vec{S}_t) = \max_{q_{jt}^0} E\pi_{jt}(\vec{S}_t, q_{jt}, \vec{q}_{-jt}, H(\vec{S}_{t+1})) + \beta E V_j(\vec{S}_{t+1}),$$

subject to

$$\begin{aligned}
\begin{bmatrix} s_{t+1} \\ x_{t+1} \\ \widetilde{c}_{t+1} \end{bmatrix} &= \begin{bmatrix} 0 & \delta & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \rho \end{bmatrix} \begin{bmatrix} s_t \\ x_t \\ \widetilde{c}_t \end{bmatrix} + \begin{bmatrix} \delta & \dots & \delta \\ 0 & \dots & 0 \\ 0 & \dots & 0 \end{bmatrix} \vec{q}_t + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \eta_{t+1} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \xi_{t+1}. \\
q_{jt} &= h_j(\vec{S}_t), \\
\text{and} \quad q_{jt} &\leq M - s_t - x_t - \sum_{j' \neq j} q_{j't}
\end{aligned}$$

# Data

- Primary Market Data: *"National Condominium Market Trends"* 1985-2000
  - Data are collected from the advertisements on condominiums more than two stories and more than four units.
  - The unit of observation is the sales phase.
  - It includes prices, units, name of developer(s),name of builder(s)as well as characteristics of the building.
  - The reported prices are likely to be higher than transaction prices.
  - Number of observations=7100.

# Data (cont.)

- Secondary Market Data: *"Weekly Housing Information"* 1991-2002
  - It is the magazine of classified ads.
  - Not all secondary market prices are observable because there are no data source that keeps track of all transactions and most properties are not transacted each periods.
  - The secondary market price for each observation in the first dataset is imputed from this data.
  - They are also likely to be higher than transaction prices.
  - Number of observations=3139.

# Data (cont.) - Summary Statistics

For technical reasons, some parameters are predetermined.

**Table 3: Predetermined Parameters**

| | value |
|---|---|
| Common discount factor($\beta$): | .975 |
| 1-period survival rate ($\delta$): | .99 |
| Scrappage price($\overline{p}$): | 45.14 million (yen) |
| Market size($M$): | 3.514 million (households) |
| Number of firms($J$): | 5 |
| Steady state cost ($\overline{c}_1$): | 25 million (yen) |
| Variance of macro cost shock ($\sigma_\eta^2$): | .71 |

# Step1: Estimation of the process of $x_t$

$$x_t = x_{t-1} + \xi_t, \tag{14}$$

where $\xi_t \sim N(0, \sigma_\xi^2)$.
$\sigma_\xi^2$ was estimated by the maximum likelihood estimation.

# Introduction of structural errors

- Demand Side

$$p_{t+1}^{d+1} = E_t(p_{t+1}^{d+1} | \Omega_t) + \nu_{i,t,t+1}^{d+1} \tag{15}$$

where $\Omega_t$ is the information available at time $t$ and $\nu_{i,t,t+1}^{d+1}$ is the forecast error by individual $i$.

- Supply Side

$$q_{jt} = h(\vec{S}_t) + \lambda_{jt}, j = 1, ..., J \tag{16}$$

where we assume that $\lambda_{jt}$ is unobserved by any firm when they make the decision and identically independently distributed to $N(0, \sigma_\lambda^2)$ across firms and time.

# Step2: Estimation of Demand Parameters($\alpha$,$\gamma_0$,$\gamma_1$)

- The basis of the estimation is the forecast errors of consumers.

$$\begin{aligned} E(w^{d+1}_{jt+1}|\Omega_t) &= 0 \\ E(y_{jt} \cdot w^{d+1}_{jt+1}) &= 0 \end{aligned} \tag{17}$$

  where $y_{jt}$ consists of variables that was known at time $t$ and varies across time and vintage.

- $y_{jt} = [1 \ ECC^d_{jt-1}]$
  They can be estimated by IV.

# Step3: Estimation of Cost Parameters($\rho$,$c_2$,$\sigma^2_\lambda$)

Let $\vec{z}_{jt}$ that is independent of the structural error $\lambda_{jt}$.

$$E(\vec{z}'_{jt} \cdot \lambda_{jt}) = 0. \tag{18}$$

$$E\vec{z}'_{jt}[(q_{jt} - h(\vec{S}_t))^2 - \sigma^2_\lambda] = 0. \tag{19}$$

Stacking conditions (18) and (19) together yields $E(Z_{jt} * \Lambda_{jt}) = 0$, where $Z_{jt}$ is the block diagonal matrix.
Its sample analogue is then given by

$$\Upsilon_s = \frac{1}{TJ}\sum_{t=1}^{T}\sum_{j=1}^{J} Z_{jt} * \Lambda_{jt}.$$

The instruments are set to be $z_{jt} = [1, q_{-j,t-1}, q_{-j,t-2}, x_t]$.

# Step3: Estimation of Cost Parameters($\rho$,$c_2$,$\sigma_\lambda^2$) (cont.)

If we observe all the variables, the parameters can be estimated by nested GMM procedure, in which the firm's dynamic programming problem is solved for each set of candidate parameters at each iteration.
However, we do not observe $\tilde{c}$. Therefore,

- $\tilde{c}$ is integrated out from the condition and
- The initial value has to be found for $\tilde{c}$ as it is serially correlated.

Thus available condition is

$$\Upsilon_{si} = \frac{1}{TJ} \sum_{t=1}^{T} \sum_{j=1}^{J} \int Z_{jt} * \Lambda_{jt}.f(\widetilde{c}|c_T)d\widetilde{c}. \tag{20}$$

From the informal information about the cost break down, I conjectured the latest value of $\tilde{c}_{1999} = 3.75$.

# Parameter Estimates

| | | | |
|---|---|---|---|
| Process of $x_t$ : | | | |
| | *MLE* | | |
| $\sigma_\xi$ | 1.003 | | |
| | (0.5636) | | |
| Observations | 15 | | |
| Demand: | | | |
| | *OLS* | *IV* | *IV* |
| $\alpha$ | .1356 | .5371 | .1930 |
| | (.0165)$^{**}$ | (.1794)$^{**}$ | (.1321) |
| $\gamma_0$ | $-5.118$ | $-4.2765$ | $-10.430$ |
| | (.2216)$^{**}$ | (.3201)$^{**}$ | – |
| $\gamma_1$ | $-4.850$ | $-3.690$ | $-8.497$ |
| | (.1570)$^{**}$ | (.7235)$^{**}$ | – |
| Observations | 15 | 13 | 216 |
| Cost: | | | |
| | *GMM* | | |
| $\rho$ | .7469 | | |
| | (.0244)$^{**}$ | | |
| $\overline{c_2}$ | 16.035 | | |
| | (4.5965)$^{**}$ | | |
| $\sigma_\lambda$ | 0.1572 | | |
| | (0.1433) | | |
| Observations | 35 | | |

Standard errors in parentheses.$**$ significant at 1% level.$*$ significant at 5% level.

# Numerical Solution

The model is solved by collocation methods.

- The solution at $s_t = 7.75$ & prices (1)

- Both policy and value functions are decreasing in all state variables.
- They are most sensitive to the macro shock measured by elasticity.
- They are more sensitive to the current fringe competitors than age 1 stock.

- The solution at $s_t = 7.75$ & prices (2)

- The elasticity of policy function with respect to each state variable is higher in absolute value in the deflationary period than the inflationary period.
- It implies that the inflationary cost works as a credible commitment device for relatively low future production.
- On the other hand, the deflationary trend works adversely to the firm. As consumer expect further decline in the prices, the exogenous increase in the fringe competitor, for example, is more harmful for the profitability of the firms.

# Simulation

- The simulation shows the model does not do well in prediction. Especially the price is over predicted.

| | $\sum q_{jt} + x_t$ | $p_t^0$ | $x_t$ | Markup |
|---|---|---|---|---|
| Mean Prediction | 11.0018 | 83.2549 | 3.4019 | 0.0170 |
| Mean Deviation from Observations | 17.5565 | 21.2345 | 13.2119 | |
| Mean Observation | 20.9481 | 53.9862 | 14.7644 | |
| Variance of Observations | 95.2835 | 95.1827 | 49.0109 | |

- The simulation is over 500 draws over 9 periods.
- The predicted price cost margin between 1992-2000 was less than 2%.
- It indicates that the market power is quite small in this market even when I assume there are 5 firms in the market.

- The analysis suggests weak evidence of the market power in the Tokyo condominium market.
- For more concrete examination, it requires to relax some of following assumptions in this model.
  - Fixed terminal value
  - Longer product life
  - Fixed number of firms
- To be conclusive, the examination of the alternative hypothesis is desired.