Hedonic Equilibrium Analysis of Property Tax Policy: Evidence from the Shenzhen Metropolitan Area

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Abstract

We develop an equilibrium hedonic pricing model designed to distinguish the 'shelter' and 'investment' values of high-rise condominium dwellings. Theory defines the necessity or shelter component as that part of the hedonic function with declining marginal price per unit of interior floor area. The investment component is defined by rising marginal price per unit because this reveals greater willingness to pay for larger units.

We suggest that the local government annually tax only the investment value to finance public infrastructure and services, and that the shelter component be protected by making the tax rate progressive. Such a tax would provide incentives for citizens to be actively involved in local government; in particular, tax rates and expenditure decisions will be of interest to property owners because tax money spent efficiently will benefit property value.

We test our hedonic method using sales of new high rise condominiums in two districts within Shenzhen: Futian and Longgang. The results show that the dividing line between shelter and investment property is about 60 square meters. Our hedonic model shows that, in equilibrium the proposed tax would have resulted in additional revenues of between 5.5% and 13% of existing real estate taxes in the year 2000, or between 380M RMB and 840M RMB per year.

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1. Introduction

This research is based on Rosen's (1974) model of hedonic equilibrium. We consider the equilibrium established after negative capitalization of a new property tax into house value. Our analysis of the demand side of the market allows us to derive inferences about the effect of a proposed annual property tax on dwelling owners in Shenzhen. The proposed tax will be compared to existing tax collections in terms of its ability to finance investments in public infrastructure and services. The role of the national government in financing economic development inside and outside the Shenzhen special economic zone (SEZ) will be factored into the policy analysis.

Our main research contribution is to use the hedonic model to distinguish between shelter and investment components of housing purchases. Specifically, consider a sample condominium with 100 square meters. Let's assume that we find empirically that the first 60 square meters shows a decreasing ability to pay for each increment to dwelling size, while the remaining 40 square meters displays rising price per square meter. Based on hedonic theory, we argue that the first 60 square meters represents a necessity commodity (i.e., shelter) while the second component is above and beyond that (i.e., it has an investment component).[1]

What if the first component were free from annual property taxation while the second component was taxed? Such a system will be reviewed with special reference to the incentives that it would provide for efficient public expenditures on infrastructure and public services.

Our hedonic model provides a new method for estimating the effects of an *ad valorem* property tax following the progressive scheme outlined above, where the degree of progressivity depends on empirical results. We use empirical results from the tax capitalization literature (Clapp, Nanda and Ross, 2008; de Bartolome and Rosenthal, 1999; Palmon and Smith, 1998) to evaluate the effect of the proposed property tax on the hedonic envelope function.[2]

Our database for Shenzhen allows us to estimate important characteristics of the utility functions of buyers in the high-rise housing market.[3] Our data are a very rich and complete representation of free market transactions of ownership units in high rise buildings (i.e.,

[1] The terms "necessity" and "investment" components are rigorously defined by hedonic theory, in Section 3.

[2] China has a very different tax system than the US, so we use a simple version of tax capitalization model in Yinger *et al*., 1988. We do not need to consider the tax deduction issues raised by Follain and Ling (1991).

[3] Data source: *Shenzhen Land & Real Estate Exchange Centre*.

condominiums) between August 2004 and January 2006. Many of the sales are presales: i.e., sold before the buildings are completed. Thus, we take our results as an approximation to the market for new housing.

As a second contribution, we propose to test for the significance of location within a SEZ on the necessity vs. investment components. This is based on a strength of our database: We have projects inside and outside the Shenzhen SEZ.

Finally, the availability of the timing of transactions allows us to track comparatively the evolution of the housing prices in and outside of the Shenzhen SEZ in each month during our sample period. We add to empirical findings with respect to Hong Kong high rise housing prices (see Leung, Leong and Wong 2006).

The next section discusses the relevance of Shenzhen in Chinese economic and housing development, and it provides an overview of existing tax policy. Motivation for an annual property tax, and application to the necessity and investment components, is discussed in this section. Section 3 develops the role of equilibrium hedonic pricing theory in identifying the boundary between necessity and investment housing demand. It argues that the simple structure of supply in the high rise housing market allows identification of the demand side. Section 4 develops a functional form for the hedonic regression and provides an overview of the tax simulation model. Section 5 presents the data and empirical results, including estimates of revenues collected from the proposed property tax. Section 6 concludes.

2. Housing and tax policy in Shenzhen and China as a whole

Shenzhen is an important engine of Chinese economic development, with population growth of roughly 15% per year fueled by in-migration.[4] Many of the immigrants have been single people seeking work for several months out of the year. But at the same time Shenzhen had about 1.2 million family households in the year 2000. This is about 5.5% of the 18.8 million family households in the sprawling Guangdong (aka Guangzhou) conurbation (Map 1).[5]

We study new high rise housing in two districts in Shenzhen: Futian (inside the SEZ and centrally located) and Longgang (outside the SEZ and peripherally located). Together, these districts comprise nearly 45% of Shenzhen's family households.

[4] The *China Daily* (November 16, 2004) reports that: "Shenzhen's population density tops large and medium cities in the Chinese mainland at 3,597 people per square kilometre. That density is growing 15.32% per year. In comparison, the population density in Beijing was 881 people per square kilometre, 2,902 in Shanghai and 975 in Guangzhou."

[5] *China Census 2000* reports that there were over 340 million family households in all of China.

The rapid growth of family housing in Shenzhen is indicated by the relatively large percentage of housing that was new (i.e., less than 10 years old) in 2000:

	Percent of Housing Units < 10 years old
Shenzhen	77%
Futian District	83%
Longgang District	79%
National	42%

Source: Authors' calculations based on *China Census 2000*, Table7-1, p 294-295, reference A and Table 11, p 811, reference B.

Moreover, 40% of Shenzhen family households own their dwelling unit. Of these, many estimate that their housing is quite valuable compared to the national median of about 15,000 RMB:

Housing Expenditure, RMB	Shenzhen	Futian District	Longgang District	National
Total	100%	100%	100%	100%
<10k	7%	0%	11%	41%
10-20k	3%	3%	2%	20%
20-30k	5%	6%	2%	10%
30-50k	8%	10%	4%	8%
50-100k	15%	17%	17%	5%
100-200k	22%	19%	26%	2%
200-300k	16%	10%	24%	0%
300-500k	13%	15%	12%	0%
>500k	11%	21%	3%	0%

Source: Authors' calculations based on *China Census 2000*, Table 7-5, p 296-297, reference A and Table 20, p 812, reference B.

The municipal government of Shenzhen is under considerable pressure to quickly expand infrastructure and public services to accommodate rapid population growth. We turn to tax policies that are relevant to the growing population in middle class and luxury housing.

Existing tax policy in China and in Shenzhen

China has a complex system of taxation at the national and local levels. Appendix 1 (China's National Taxation System, 2005) and Appendix 2 (Important Changes in China's Real Estate Tax Policies) provide some details. These appendices are available from the authors on request.

At the national level, important real estate taxes include: 1) A deed tax (transfer tax) of 1.5% on sales of residential units and 3% on certain other properties; 2) A 5% tax on the selling price of properties held less than 5 years; 3) Land Appreciation Tax (LAT) , a percentage of appreciation over allowed deductions. Existing sources of revenue in Shenzhen include an education surcharge at the rate of 3% of paid business tax.

Land revenue includes state-owned land leases, land use fees and other income related to land.[6] Land revenue is collected into a special government fund and exclusively used in land requisition compensation, affordable housing development, and urban infrastructure. The national government does not provide financial support, but offers policy incentives for social and economic development of Shenzhen. The largest policy benefit for Shenzhen: only 15% of the enterprise income tax (EIT, described in Appendix 1) applies to Shenzhen's special economic zone. Other policy incentives have been eliminated in recent years.

Why impose an annual property tax?

The property tax has an important advantage over other taxes: it makes property owners into stakeholders in the local government. If revenues from the property tax are spent efficiently on local infrastructure and local public services, then property values will rise enough to partially or wholly offset the burden of the property tax. Therefore, property owners have an incentive to be actively involved in local government affairs and monitor the efficiency with which officials spend tax money. A second advantage of the property tax is that real property is observable and verifiable. Therefore, it is difficult to avoid taxation by concealing real assets.

6 Land use fees rather than land use taxes are applied in Shenzhen. The rates depend on land use fee type, land type and land class. However, land use fees have been replaced by land use tax in Shenzhen since November 2007, according to the Announcement of Shenzhen Local Tax Bureau on Starting to Levy Urban Land Use Tax. The land use tax started to be collected from June 1, 2008. Residential units occupied by owners are exempt. Land revenues in 2002, 2004 and 2005 for Shenzhen were RMB 14.263 billion, RMB 11.64 billion and RMB 12.92 billion, respectively. Further, real estate related tax revenue was RMB 4.984 billion in the first five months of 2007. This accounts for 19.6% of local tax revenue. It should be noted that it is extremely difficult to collect data regarding land revenue and real estate related tax revenue.

The often-cited disadvantages of the property tax have limited applicability to the progressive investment tax proposed here. It is often alleged that the property tax imposes a higher burden as a percentage of income on lower income households.[7] But the tax proposed here is specifically designed to be progressive.

Another major criticism of the property tax is associated with the difficulty of determining the value of real property. Some properties trade infrequently, are in unusual locations or have characteristics that are difficult to value. However, the property tax proposed here is based on the living space of new high rise apartments. This property class is relatively homogenous and easy to value with recent transactions prices.

We propose to set a maximum tax rate on properties above 110 square meters. Moreover, properties above 110 square meters will be valued based on their size, not on other characteristics. Therefore, the tax will be based uniformly on observable characteristics of the property and on the hedonic regression proposed below. There will be minimal judgment involved on the part of the tax assessor.

3. Hedonic equilibrium theory applied to high-rise housing

The hedonic model provides a theory for the equilibrium pricing for each characteristic of a bundle of characteristics that are sold in inseparable units.[8] Consider a single characteristic, such as interior area (square meters) of a unit. The theory says that the larger the size of the unit, the higher the bundle price must be, holding constant for other characteristics. Thus, equilibrium rules out the possibility that one can buy larger units for a lower total price. However, the theory does not predict whether the price per *unit* declines or rises with the equilibrium quantity in the market. Rosen's seminal work emphasized the case where price per unit rises with quantity, but he does not discuss the implications of this.

Figure 1 illustrates the case where price per unit rises as the quantity increases; i.e., the hedonic pricing function is convex to the X-axis. For the moment, suppose that the cost per unit of production of interior area is constant; i.e., marginal and variable costs are identical and equal to a constant. Then the convex hedonic pricing function must mean that higher income households (or those with a greater taste for larger units) are willing to pay more per unit than the lower income households. In effect, this means that there are relatively more of these

[7] This is a debatable claim because local public services are also oriented towards lower income households. For a discussion, see Goodman (2006), Listoken, Listoken and Voicu (2006), Peterson (2006), Peterson (1973) and Netzer (1966).

[8] Rosen's (1974) theory has been generalized by Bajari and Benkard (2005). Most importantly, the generalization allows for discontinuous supply of bundles of hedonic characteristics.

households compared to the supply of these large housing units on the market. Thus, the bidding among higher income households causes the price per square meter to rise as the number of square meters increases.

Our empirical evidence indicates that the convex pricing function illustrated in Figure 1 holds for high-rise housing above 60 square meters. Identification of the demand side is obtained because cost to build should be *less* for larger units; plumbing and kitchen facilities are spread over more area and fewer partitions are required. *Thus, if the equilibrium is as described in Figure 1, land owners must be making a higher profit on the larger units.* This may occur in a supply constrained market where it is difficult both to get permission to build and to forecast the demand for units of various sizes.

Implications for shelter vs. investment goods

Hedonic equilibrium theory says that supply and demand match (pair off) at different bundles of characteristics. Ekeland, Heckman and Nesheim (2004) emphasize that supply-demand pairings are essential because in equilibrium the market must clear for every bundle being sold in the market.

Given these pairings, and the fact that supply costs decrease for larger units, why would buyers pay more per square meter for larger apartments (Figure 1)? They must have the income and/or taste associated with higher demand for larger units. But, it is common knowledge that many high-rise apartments in Shenzhen are sold to investors. So the "taste" for larger units likely comes from an investment motive: the costs of carrying the investment (management costs) can be spread over more square meters, lowering the opportunity cost of the investment. This characterization of the investment motive is an approximation that does not apply to every transaction. Consequently, we define the "investment component" to mean that portion of the hedonic function with rising marginal costs.[9]

Those demanding larger housing units could shift their demand to the smaller end of the market. This is likely to happen if buyers have a shelter motive. That is, if the hedonic envelope function is shaped as in Figure 1, they can obtain basic shelter at lower cost per unit by buying smaller apartments.

Proposed policy: Progressive annual property tax

[9] Likewise, the terms "necessity" or "shelter" component are defined here to refer to the part of the hedonic function with declining marginal cost per unit of interior area, or the minimal amount of area if the hedonic function is convex throughout its range as in Figure 1.

China does not have an annual *ad valorem* property tax. However, our results indicate that there is an ability to pay this tax if it were imposed on the larger units. The property tax imposed on such units would reduce their total value, but the convex hedonic equilibrium illustrated in Figure 1 and supported by our empirical results indicates there is considerable room to pay such a tax and still have a functional market for large units. Figure 2 illustrates the effect of imposing a progressive *ad valorem* property tax above a minimal size, $\overline{Q}_1$. Just above $\overline{Q}_1$ the percentage tax rate is near zero; it rises to a maximum tax rate at $\overline{Q}_2$. Thus, the tax is a progressive percent of property value.

The progressive aspect of the proposed tax minimizes incentives to shift the production of housing to an amount just below $\overline{Q}_1$: the tax saved by small adjustments in production will be small. In this way, the proposed tax has an advantage over the property tax as implemented in the US and many other countries, where there is an incentive to hold vacant land rather than to build structures. The proposed tax provides no disincentive to build necessary shelter, and taxes the investment component only where the hedonic function is convex.

When the market reaches equilibrium after the tax, demand for investment apartments will be reduced as illustrated by comparing the dashed line to the solid line in Figure 2. The market prices of these apartments will fall as the tax is negatively capitalized (see Yinger *et al*., 1988). Of course, the equilibrium price of investment units will still be higher than those of smaller apartments as required by the theory of Rosen (1974).

Figure 2 illustrates the effect of the tax on price, but there will be a corresponding reduction in the equilibrium number of units built and sold at each size above $\overline{Q}_1$. This follows from the pairings between supply and demand, where a number of buyers and sellers reach equilibrium at each quantity of the hedonic characteristic, $\overline{Q}$.[10] We allow for the negative equilibrium demand shift in number of units and price when we simulate the effects of the proposed property tax.

The hedonic model with monopolistic competition

We model monopolistic competition in the supply of hedonic characteristics in the high-rise housing market in Shenzhen. The assumption of monopolistic competition is appropriate on several counts:

[10] See the discussion of Figure 1 in Eckland, Heckman and Nesheim (2004). The role of general equilibrium adjustments in response to taxes is discussed in Gyorko and Sinai (2003).

1. Spatial markets are inherently monopolistic because each location in space is unique;
2. Sites suitable for the development of high rise housing are in limited supply;
3. Permission from the local government to build is in limited supply.

The hedonic model with monopolistic competition has long been developed in the literature (see Dixit and Stiglitz, 1977). We use a version recently implemented by Pakes (2003). In this model price is a function of the vector of hedonic characteristics (simplified here to the size of the unit) and so are marginal cost and the elasticity of demand.

$$P(size) = mc(size) + 1/e_D(size) \qquad (1)$$

where $e_D(size)$ is the absolute value of demand elasticity with respect to size of the unit (interior square meters), $mc(size)$ is the marginal cost of supplying space and $P(size)$ is the hedonic envelope function illustrated in Figures 1 and 2. Our focus on size is standard in the housing literature: i.e., people are paying for elbow room more than anything else.

Equation (1) says that the equilibrium hedonic envelope is equal to the marginal cost of supplying space plus a markup, which is higher for more inelastic demand. Pakes (2003) points out that this equation holds exactly for Bertrand competition; the markup becomes a complex function of the distribution of ownership and preferences when we depart from this simple assumption. However, equation (1) provides a valuable insight: the elasticity of demand is a key parameter. The simple structure of supply in the high rise housing sector allows us to identify demand as indicated by equation (1).

Our assumption is that, in the high rise sector, marginal cost has a particularly simple form. All units have a kitchen and a bathroom, the main fixed components of cost when constructing a unit. Moreover, construction costs will increase with the number of floors. The increase is particularly large after about five floors when construction materials must be lifted with cranes and other heavy construction equipment. So we take mc() as constant depending on the floor number.

We turn to an empirical model that allows flexible measurement of demand elasticity.

4. Functional form for the empirical model

We allow flexibility in the estimate of the elasticity parameter with a Taylor expansion in the log of interior area (size). The Taylor expansion is well established and the use of the log

form is standard in the hedonic literature.[11] The log linear model would have constant elasticity. The squared and cubed terms for the log of size allow the flexibility we seek to accurately measure changes in elasticity with respect to the amount of space being purchased.

$$\ln price = \beta_0 + \beta_1 \ln(size) + \beta_2[\ln(size)]^2 + \beta_3[\ln(size)]^3 + I(type,\ floor, month) + U(\varepsilon) \quad (2)$$

where *size* is measured in square meters; $I()$ refers to indicator (0,1) variables; *type* refers to dwelling type (e.g., a townhouse or a 2 bedroom flat); *floor* indicates height of the unit above street level; and *month* is each month where sales took place.[12] The disturbance term is a result of negotiation between buyer and seller. The function $U(\varepsilon)$ allows for possible spatial autocorrelation in disturbance term, ε, an important factor given the large literature providing evidence for spatial structure.

Simulation of the proposed tax

Arc elasticities of demand will be estimated from the β parameters in equation (2), with other variables held at selected values (e.g., the 5th floor and the first month). To calculate arc elasticities, we simply estimate predicted price for each level of size, then find the percent change in price for a one percent change in size.

The negative demand shift from imposing a tax on a unit of given size is estimated from the elasticity parameters. Data in *China Census 2000* allow estimation of the number of housing units in each size category. We calculate the number of units, and the equilibrium price, after allowing for the negative demand shift. Then it is straightforward to tabulate the tax that will be collected depending on the percentage taxed, the interest rate and the rate at which the property tax is capitalized into value.

Details of the algorithm for calculating tax collected are given below.

5. Data and empirical results

Shenzhen database and variable definitions

[11] An advantage of the log form is that is reduces heteroscedasticity in the disturbance terms. The source of the disturbance terms is negotiation between buyers and sellers and these negotiations are likely to take place in terms of percentage of the selling price. Therefore, the log model is a natural one to use.
[12] It is well known that in China, certain floor numbers are considered unlucky, so demand should decrease for apartments on these floors.

We have collected and edited an extensive database on free market transactions of high density condominium units in the Shenzhen region. Our original dataset contains 10,252 sales transactions with information on (a) sales price, (b) square meters of floor space, (c) a project identifier (which also identifies whether a property is inside or outside of the SEZ), (d) a building identifier, (e) unit type (one bedroom through four bedroom, duplex, greater than four bedrooms, single apartment and single dormitory), (f) floor number, and (g) date of sale.[13] The date of sale ranges from August 2004 to January 2006, with exact day of sale included in the data.

Our dependent variable is the natural logarithm of the transaction price, Totprice, of a sample property, ***Inprice***. The independent variables of the model are defined as follows:

- ***F(i) or L(j)*** = 1 if a sample housing unit is located in housing project Futian, denoted by i or Longgang, denoted by j, 0 otherwise (where i = 1,2, ..., 11 and j = 1, 2, ..., 5);
- ***Type1*** = 1 for 1-bedroom or single apartment or single-dormitory housing units, 0 otherwise;
- ***Type2*** = 1 for 2-bedroom housing units, 0 otherwise;
- ***Type3*** = 1 for 3-bedroom housing units, 0 otherwise;
- ***Type4*** = 1 for 4-bedroom housing units, 0 otherwise;
- ***Type5*** = 1 for duplex or 'more-than-4-bedroom' housing units, 0 otherwise[14];
- ***Insize*** is the natural logarithm of the square meter of a given sample housing unit;
- ***Month (k)*** = 1 if a sample housing unit was sold in month k, 0 otherwise (k=1, 2, 3,…, 18; Month1 is August 2004);
- ***Floor1*** = 1 if a sample housing unit was located between the first and the fifth floors of a given housing project (F(i) or L(j)), 0 otherwise;
- ***Floor2*** = 1 if a sample housing unit was located between the sixth and the tenth floors of a given housing project (F(i) or L(j)), 0 otherwise;
- ***Floor3*** = 1 if a sample housing unit was located between the eleventh and the fifteenth floors of a given housing project (F(i) or L(j)), 0 otherwise;
- ***Floor4*** = 1 if a sample housing unit was located between the sixteenth and the twentieth floors of a given housing project (F(i) or L(j)), 0 otherwise;
- ***Floor5*** = 1 if a sample housing unit was located between the twenty-first or the twenty-fifth floors of a given housing project (F(i) or L(j)), 0 otherwise;

[13] A subset of the above data contains the 6,411 sales where we have some project information. These are projects F1-F5, L1 and L2. The project information includes size of the project, floor area ratio, parking, availability of common facilities, availability of daycare within the project, management fee, date construction began and presence of a special economic zone as well as other information. When needed, these data supplement our larger dataset.

[14] Due to limited number of observations, single apartment or single dormitory (more-than-4-bedroom) transactions are combined with 1-bedroom (duplex) transactions, respectively.

- ***Floor6*** = 1 if a sample housing unit was located between the twenty-sixth and thirtieth floors of a given housing project (F(i) or L(j)), 0 otherwise;
- ***Floor7*** = 1 if a sample housing unit was located between the thirty-first or the thirty-sixth floors of a given housing project (F(i) or L(j)), 0 otherwise.

We study separately two sub-samples -- one for the properties inside the SEZ, which are located within the Futian District (6,998 observations), and a second one for the properties outside the SEZ, which are located within the Longgang District (3,254 observations). Further screening of the data for each sub-sample reveals that (a) there are no observations for the Futian sub-sample in August, September, and October of 2004, (b) the Futian sub-sample has only 25 observations in January 2006, (c) the Longgang sub-sample has no observation on single apartment or single dormitory transactions and has only four observations on transactions for the 'more-than-four bedroom' properties, (d) projects F6 and especially F7 in the Futian sub-sample have few observations and (e) the Longgang sub-sample does not have any Floor7 observations. Given that one of our objectives is also to construct a price index for each sub-sample, we exclude the month of January 2006 from the Futian sub-sample to avoid an unreliable price index estimate for January 2006. This exclusion leaves a total of 6,973 observations for the Futian sub-sample.

The data and variable restrictions affect our model specifications and estimations for each sub-sample in a number of ways. For the Futian sub-sample, we observe the following empirical issues. First, the omitted base month is November 2004 (i.e., Month4) since there is no observation for August, September and October of 2004. Hence, all estimates for the monthly dummy variables shift in relation to November 2004. Second, the presence of only a handful of observations for January 2006 (i.e., Month 18) forces us not to include a dummy variable for Month18 in our estimations. Third, project F7 is the omitted category; all estimates of the project-related dummy variables shift in relation to F7, which has only a few observations.

For the Longgang sub-sample, we have no observation on Floor 7 and have a small number of observations on Floor 6, which, as a result, is designated as the omitted category in relation to Project1 through Project5.[15] Further, Type1 consists entirely of 1-bedroom properties and serves as the omitted category. Each sample month has sufficient number of observations. So, August 2004 (Month1) is the omitted category for this sub-sample.

Table1 - Panel A and Panel B provide summary statistics for each sub-sample. The mean, median and standard deviation of transaction prices in RMB for the Futian District are 670,932, 431,592, and 821,977 while the corresponding figures for the Longgang District are

[15] Not surprisingly, the average building height is larger in Futian, the more central location.

549,365, 422,705, and 487,068. The average price per square meter of floor space for the Futian District is 60.5%[16] higher than that for the Longgang District (9,723.65 vs. 6,058.95 RMB). This contrasts with the size of a Futian unit, which is only about 60% of the size in the Longgang District. This is preliminary but strong evidence for the added value per unit size of being located within the SEZ in Shenzhen. We find that higher location value inside the SEZ (e.g., the value of better access to the central business district and to Hong Kong) implies less demand for investment apartments.

Figure 3 further explores the distribution of the important size variable. Both districts have right-skewed distributions (median less than mean). Both have a long tail above about 110 square meters. We will use 110 as the maximum size for the progressive property tax (i.e., the tax rate reaches a maximum at 110 sm) because we do not want to extrapolate our elasticity estimates to a thin part of the distribution.

Regression results

Table 2 – Panels A and B contain representative results for four specifications of a logarithmic hedonic pricing model estimated by ordinary least squares (OLS). Models 1 and 2 (3 and 4) are cubic non-linear and linear specifications in ***Insize*** and include (exclude) property types in the estimations, respectively.[17]

Irrespective of the functional form of the model and sub-sample, results demonstrate a strong association between size and property prices. In particular, all size-related estimates for the cubic model specifications for each district are statistically significant. This association for the Futian District, however, is stronger than that for the Longgang District. The significance levels for the estimates of the Futian District are higher than the 1% level while, for the Longgang District, the estimates for ***Insize*** and ***Insize-squared*** attain only 10% and 5% significance levels under Model 1.

Equilibrium hedonic prices are expected to increase with height of the floor. On the demand side, residents prefer to reside in higher floors where the view is better and street noise is less audible. On the supply side, floor level adds extra construction costs since materials must be lifted up and, above about five floors building core is lost to elevator shafts. The increasing equilibrium hedonic price with floor level (see definition above) is strong and applicable to all floor levels (up to the seventh level) in almost a monotonic way for the Futian

[16] Based on the medians, this amount is 64.98%.
[17] We also estimate a quadratic specification of the hedonic pricing model. We do not report these results. They are available from the authors upon request.

District. It is strong only for the first three floor levels (i.e., through floor 15) for the Longgang District.

Average price movements in each sample district show an increasing but different trend. The coefficient estimates for the monthly dummy variables for the Longgang District exhibit strong statistical significance and an overall increasing trend in relation to August 2004. The only exception is the statistically non-significant estimate for September 2004. Results for the Futian District also suggest an increasing trend, albeit a statistically less convincing one, in the average monthly prices in relation to November 2004. In fact, the coefficient estimates for December 2004, January 2005, February 2005 and April 2005 do not attain statistical significance while March 2005 attains significance only at the 10% level.

Type dummy variables have the expected effects. The least desirable type of condominium (1 bedroom or single-dormitory units, denoted Type1) has a negative effect on hedonic value both inside and outside the SEZ. The most luxurious units (duplex or more than 4 bedrooms, denoted Type5) are only available in the more centrally located Futian District. These apartments strongly increase price.

The empirical results described in Table 2 (Models 2 and 4) indicate that the price per square meter in the high-rise housing sector increases as the interior area of dwellings increases. This is after holding constant for characteristics of the units. This is the standard hedonic result: larger units are priced higher and the t-values indicate that interior size is much more important than any other variable in the regression.

When Panel B is compared to Panel A, the surprising result is that elasticity of price with respect to size is much larger in Longgang (1.69) than in Futian (1.05); both numbers are for the models that control for unit type. Since the regression passes through the means, the much larger elasticity in Longgang may follow from nonlinear effects over the range of lnsize. Therefore, we add a squared and cubed term for lnsize.

Table 3 shows that the investment condominiums (elasticity increasing) begin at about 60 square meters both inside and outside the SEZ. But inside the SEZ the hedonic function shows less convexity above 60 square meters, indicating less demand relative to supply of "investment" condominiums.

The calculations in Table 3 show some interesting differences inside and outside the SEZ. Outside prices are estimated at about 60% of those inside, controlling for characteristics and for time.[18] Table 1 shows that the minimum size of an outside unit, at 42.5 square meters is much larger than the 27.5 square meters of an inside unit. Thus, the less centrally located units

[18] The "type" variable is omitted from the specification used for calculations in Table 3.

are priced less (i.e., land value is less) and allow bidding on relatively large units. This is consistent with the elasticity results.

Robustness checks: Allow flexible marginal cost

We performed a number of alternative model specifications in order to check the robustness of the main findings. First, we removed outliers: i.e., observations that are very influential in terms of the results. This was done with standard methods for measuring Cooks-D statistics to identify outliers.

The standard errors for our coefficients are measured using robust clustered standard errors. Standard errors were clustered within each building in order to avoid spatial dependence within the buildings. Moreover, Huber-White standard errors were calculated.[19]

We allowed a number of different model specifications. The elasticity, the main parameter in equation (1), was calculated for each model specification. Without exception, the elasticities were not sensitive to model specification.

A plausible objection to these results is that marginal costs differ depending on the floor of the unit. It is more costly to build an additional square meter at level 2 or higher (i.e., above 5 floors) because construction materials must be lifted; higher floors can be associated with substantially heavier construction equipment. If marginal costs differ across units, then estimated elasticities may be inaccurate.

We re-estimated the model allowing marginal cost to differ by floor level. In particular, we shifted the parameters of the model for the 5^{th} floor and above. The coefficient estimates from these models differ substantially from those in Table 2. However, the elasticity estimates do not change much. For example, on a high floor in Futian, the demand elasticity falls to about 1 at 60 square meters and rises to about 1.04 at 110 square meters. These results are substantially the same as in Table 3. On the first five floors, elasticity falls to about .93 at 70 square meters and stays close to that level, and then rises at 100 and again at 110 square meters.

We conclude that our main results are robust to allowing flexible marginal costs.

Estimating collections from the property tax

[19] This well established method is based the variance covariance on the residuals from an ordinary regression. These residuals are then weighted by the X-values.

Table 4 uses arc elasticity estimates to measure the amount collected from the proposed tax in hedonic equilibrium. The algorithm used for these calculations follows the general model framework discussed in Section 4. The steps involved in the estimation model are as follows:

1. Construct an equal interval grid from the minimum of about 20 square meters to a maximum which is within range of the observed data (see Figure 3).
2. Use estimated coefficients from the hedonic models to calculate predicted price at each point on the grid and at fixed values for the remaining hedonic characteristics.
3. Multiply predicted price by the proposed annual property tax for square meters of 60 and above.[20] i.e., the progressive tax rate is zero percent at less than or equal to 60 square meters.
4. The property tax rate increases linearly from zero percent to a maximum percentage rate such as 1% or 2%. The maximum determines the progressivity of the proposed tax.
5. The percent change in equilibrium hedonic value is estimated from the change in price induced by the tax, the capitalization rate, and the percent of the tax capitalized into value.[21]
6. The total number of units in each size category is estimated from *China Census 2000* and the distribution of sales by size.
7. The total number of units in equilibrium after the negative demand shift is estimated from steps 5 and 6 above; i.e., multiply $1/e_D$ by the percent change in price. Thus, the model allows for the change in demand that results from implementing the tax.
8. The tax collected is simply the tax rate times the equilibrium number of units times the predicted price per unit from the hedonic regression.
9. Sum the estimate tax collection over all the size categories to obtain the total annual collection estimated, Table 4.

In Table 4, the degree of progressivity was controlled by the maximum tax rate. That is, the tax rate starts at zero percent for 60 square meters and increases linearly up to a maximum percent at 110 square meters. This maximum was chosen based on the range of the data as

[20] The area of 60 square meters was chosen because the empirical results show that this is where the hedonic function changes from concave to convex: $\overline{Q}_1$ in Figure 2.

[21] A parameter here is the percent of the tax capitalized into value. This is based on US studies, which show that the percentage ranges from about 0.3 to 0.9 in decimal terms.

illustrated in the histograms, Figure 3. Above 110 square meters the estimators of elasticity were not reliable enough to form the basis for a property tax.

A mildly progressive property tax has a maximum rate of 1% at 110 square meters. A more progressive tax rate has a maximum at 2% at 110 square meters. Two percent is roughly the average property tax rate in the United States.

The effect of the tax also depends on the percentage capitalized into property value. More myopic homeowners capitalize a smaller percentage. Results in the US suggest that between 30%-90% of the tax is capitalized; in theory, the percent capitalized depends on the relative mobility of the population and of capital.[22] The higher the percentage of the tax capitalized the more negative the effect of the tax would be on the demand for investment housing. Therefore, demand will shift down and in equilibrium a smaller total tax will be collected.

The results indicate that the tax collected in the two areas combined would range from about 170M RMB to about 375M RMB per year. Since Futian has fewer large units, less tax is collected there; i.e., Futian has a smaller investment sector as suggested by Table 3.

The largest determinant of the amount collected is, of course, the progressivity of the tax as measured by the maximum tax rate. The next influential factor is the amount of the tax capitalized into value: i.e., the degree of myopia in the market. The discount rate is not influential.

We estimate that Shenzhen collected about 6.8B RMB in the year 2000 from the various real estate taxes discussed in Section 2.[23] This implies that the proposed tax will result in an addition of between 5.5% and 13% to existing real estate taxes. The increase is modest because we propose to tax only the investment component of new high-rise housing units.

The modest impact of the tax is confirmed by China Census 2000 which shows that only 11% of units in Futian (14% in Longgang) were greater than 50 square meters. Even though most of these are new (about 77% of all units were built within 10 years), the tax would affect only the 8% of all families in Shenzhen with larger, new units.

6. Conclusions

[22] Clapp, Nanda and Ross (2008) find up to 70% negatively capitalized whereas Palmon and Smith (1998) find about 62% capitalized. de Bartolome and Rosenthal (1999) find results indistinguishable from full capitalization.

[23] We estimate that real estate taxes were about 20% of total taxes of about 35B in 2000. In addition, about 13B was collected in land leases and other income related to land.

Rapid economic growth in Shenzhen poses two related problems: providing housing for the population and providing infrastructure and local public services. When housing is owned by residents, then owners have an incentive to be actively involved in local government.[24] The property tax focuses this incentive on efficient expenditure of tax dollars.

China has a complex system of taxation at the local and national levels. We propose to add an annual property tax based on the value of high rise ownership apartments ("condominiums"). Our proposed tax is progressive so as to minimize the disincentive to build basic shelter. Only about 8% of Shenzhen families would pay any property tax and most of these would pay minimal amounts. However, even small amounts provide incentives to be actively involved citizens.

Given the need to provide shelter, we propose to tax only the investment component of housing. Hedonic pricing theory is used to define the investment component as those apartments where price per square meter increases with size. We use this concept to test for an inflection point where price per square meter changes from declining to rising: i.e., the hedonic envelope function changes from concave to convex. Moreover, we use hedonic theory to develop a new method for estimating the effect of introducing a property tax after allowing for the negative demand shift that will result.

We test our hedonic method using sales of new high rise condominiums in two districts within Shenzhen: Futian and Longgang. The results show that the dividing line between shelter and investment property is about 60 square meters. Our tax impact model shows that the proposed tax will result in additional revenues of between 5.5% and 13% of existing real estate taxes, or between 380M RMB and 840M RMB per year.[25] These modest amounts will allow the local government to be more efficient in its response to the pressure for rapid economic and residential development.

Our results indicate substantially more demand for investment housing in Longgang, outside the SEZ. In the more centrally located Futian district, land values are higher, buildings tend to have more floors and living space is more restricted. There are fewer investment units as defined by a convex hedonic function. Moreover, prices were rising much less rapidly inside the SEZ (.7% per month) than outside (1.6% per month) during the period covered by our data (the last few months of 2004 through the end of 2005).

[24] *China Census 2000* shows that about 44% of family households in Shenzhen own their residence.
[25] All estimates are adjusted to hold as of the year 2000.

Appendix 1 [Available from Authors on Request]: China's National Taxation System, 2005

Under China's national taxation system, there were 13 types of taxes[26] that applied in 2005 and to the projected REIT regime. Those taxes can be classified into three levels, i.e. taxes at the (1) enterprise level, (2) asset level and (3) investor level.

A1.1. Taxation at the Enterprise Level

At the enterprise level, there are three main types of taxes, i.e. enterprise income tax (EIT), income tax on enterprises with foreign investment[27] and foreign enterprises[28] (FEIT), and withholding tax. There is no separate capital gain tax in China's taxation system. Instead, capital gains add to other taxable income for income tax purpose.

EIT: EIT applies to SOEs, collective enterprises, private enterprises, joint operation enterprises, joint equity enterprises, and other organizations except enterprises and organizations with foreign capital participation (FEs). The tax base of EIT includes enterprises' worldwide income from production and business operations and other sources. Distributed income is not a deductible item for EIT purpose. The rate of EIT is currently 33 percent of taxable income but will be reduced to 25 percent when the EIT Law comes into effect on 1 January 2008.

FEIT: Income and capital gains received by the FEs are subject to FEIT. The tax base of FEIT is the taxable income derived from sources within China[29] after allowable deduction for costs, expenses and losses[30]. The stipulated rate of FEIT is 33 percent of taxable income, but actual rate of FEIT varies across different regions within China. Specifically, FEIT at a rate of 15 percent applies to the FEs in special economic zones and economic and technological development zones; while 24 percent is for those coastal economic open zones. Most FEs are borne to an actual average income tax burden of 15 percent[31]. It is worth to note that a universal EIT unifies both EIT and FEIT with a flat rate of 25 percent under the EIT Law. The universal EIT will come into effect on 1 January 2008[32].

Withholding tax: Withholding tax rather than FEIT applies to taxable income of those foreign enterprises which "has no establishment or place in China but which derives profits, interest, rent, royalties or other income from sources in China, or which, though it has an establishment or place in China, derives such income and the income is not effectively connected with such establishment or place" (article 19 of the Income Tax Law on Enterprises with Foreign Investment and Foreign Enterprises (the FEIT Law)). The rate of withholding tax is 20 percent of taxable income, but the actual levying rate is ten percent, which is stipulated in the tax circular of Guofa [2000] No.37[33]. The rate will restore to 20 percent under the provisions of the EIT Law.

A.1.2. Taxation at the Asset Level

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[26] Another tax, fixed assets investment orientation regulation tax, is related to real estate. But this tax has been temporarily suspended. Source: SAT, http://www.chinatax.gov.cn/n480462/n480483/n480675/n761721/n763583/index.html.

[27] Enterprises with foreign investment include Chinese-foreign equity joint ventures, Chinese-foreign contractual joint ventures and wholly-foreign owned enterprises.

[28] Foreign enterprises include foreign companies, enterprises and other economic organizations which have establishments or places in China engaged in production or business operations or which, though without establishments or places in China, have income from sources within China.

[29] However, enterprises with foreign investment with head office in China shall pay income tax on their worldwide income.

[30] Source: Beijing Local Taxation Bureau, http://english.tax861.gov.cn/zgszky/zgszky.htm.

[31] Source: Xinhua, http://www.chinese-embassy.org.uk/eng/zt/lhzt/npc/t304720.htm.

[32] *The EIT Law* prescribes a 5-year transition period for FEs to adopt the new rates of both EIT and withholding tax.

[33] It was promulgated by the State Council in 2000.

At asset level, taxes apply to acquiring, owning, renting and disposal of properties. Such taxes include business tax, land appreciation tax (LAT), city maintenance and construction tax (CMCT), farmland occupation tax (FOT), urban and township land use tax (LUT), house property tax (HPT), urban real estate tax (URET), stamp tax and deed tax. Among them, LAT, FOT, LUT, HPT, URET and deed tax only apply to real estate. The rest types of taxes apply to other business as well.

Business Tax: Business tax applies to taxable service provisions, intangible assets and immovable properties transfer. The rate of business tax ranges between 3-20 percent of turnover and actual rate depends on the nature of tax items. Business tax is levied at 5 percent of rental income or capital gains on disposal of property.

LAT: LAT adapts progressive rates, that is, the rate of LAT ranges between 30.0-60.0 percent of the proceeds derived from property sale after the allowable deduction. The actual rate depends on percentage of appreciation value over the allowable deduction.

CMCT: The levy of CMCT is based on the paid VAT, Consumption Tax and/or Business Tax. Rate of CMCT varies in different areas, i.e. it is seven percent for city area, five percent for county and township area and one percent for other areas.

FOT: FOT only applies to real estate development where it involves in using farmland. The rate of FOT depends on average farmland per capita in a given area. That is, the annual amount of FOT is RMB 2-10 per square meter for counties with one mu[34] or less of farmland per capita, RMB 1.6-8 for counties with 1-2 mu farmland per capita or, RMB 1.3-6.5 for counties with 2-3 mu farmland per capita; and RMB 1-5 for county with over three mu farmland per capita.

LUT: LUT applies to all enterprises and individuals that own or use properties. The rate of LUT depends on administrative areas. That is, the annual rate of LUT per square meter is RMB 1.5-30 in large cities, RMB 1.2-24 in medium-size cities, RMB 0.9-18 in small cities, or RMB 0.6-12 in mining districts.

HPT: HPT could be calculated in two ways. One is the cost approach in which an annual rate of 1.2 percent applies to the residual value of a property after subtracting 10-30 percent from the property's original value. The other is the rental approach in which the rate of 12 percent applies to the rental income from the property under question[35].

URET: Similar to HPT, there are two methods for calculating URET. One is the cost approach in which an annual rate of 1.5 percent applies to the value of the property. The other is the rental approach in which the rate of 15 percent applies to the rental income from the property under question[36].

Stamp Tax: Stamp tax applies to contracts and agreements. The rate of stamp tax depends on the nature of contracts. In particular, tenancy agreements, property insurance contracts and property transfer contracts are levied at the rate of 0.1 percent, 0.1 percent and 0.05 percent of the total contractual sum, respectively.
Deed Tax: Deed tax applies to property transfer contracts. It is a flat rate of 3.0-5.0 percent levied on the total contract sum. The actual rate is determined by the local government at the provincial level.

Fees and Surcharges: Besides the above taxes, various types of fees and surcharges may be applicable at asset level in different administrative areas. For example, flood prevention fee[37] is applicable in Guangzhou and education surcharge[38] is applicable in Shanghai.

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[34] Mu is an area unit used in China. One mu is approximately equal to 666.7 square meters.
[35] Source: articles 3 and 4 of the *Interim Regulations on House Property Tax,* which was promulgated on 15 September 1986.
[36] Source: article 6(3, 4) of the *Interim Regulations on Urban Real Estate Tax,* which was promulgated on 8 August 1951.
[37] Source: GZI REIT (00405.HK) IPO prospectus.
[38] Source: Greentown China Holding Limited (03900.HK) IPO prospectus.

A.1.3. Taxation at the Investor Level

Taxes on institutional and individual investors are governed by different tax legislations and regulations. Institutional investors' taxation is regulated by the Provisional Regulations of State Council of PRC on Enterprise Income Tax[39] and the FEIT Law, and by the EIT Law from 1 January 2008 onwards. Institutional investors pay taxes for their income derived from investments as they do on their production and business operation unless otherwise stated. Both domestic and foreign institutional investors pay business tax at the standard rate on income derived from their investments. Domestic institutional investors pay taxes on their investment income at the standard EIT rate; while foreign institutional investors are subject to FEIT or withholding tax depending on their legal status within China and the status of income derived from sources within China.

On the other hand, taxes on individual investors are governed by the Individual Income Tax Law (the IIT Law). The individual income tax (IIT) with a flat rate of 20 percent applies to individual investors on their income and capital gains derived from "interest, dividends, bonuses, lease of property, transfer of property, incidental income or income from other sources" (article 3(5) of the IIT Law). The amount of taxable income from such sources "shall be the full amount received in each payment" (article 6(6) of the IIT Law). The IIT is levied at income sources, that is, "the paying unit or individual shall be the withholding agent" to withhold taxes applied to individual income (article 8 of the IIT Law). It is then investigated tax arrangements for investors investing in different vehicles.

CRE (Chinese Listed Real Estate Company) Investors: Institutional investors are liable to business tax and EIT regarding their investments in CRE shares. Specially, capital gains, dividends and other income derived from such investments add to other taxable income of an institutional investor for EIT or withholding tax purpose depending on its legal status within China. Institutional investors are also liable to pay 5 percent business tax on capital gains from share trading[40]. Foreign investors are liable to withholding tax on income and capital gains derived from their investments in CRE shares. The NCSSF is exempt from both business tax and EIT regarding its share investments including investing in CRE shares[41]. Qualified foreign institutional investors (QFIIs) are exempt from business tax on capital gains derived from share investment[42].
Individual investors are exempt from IIT on capital gains of share investments including CRE shares. Dividends received by individual investors are taxed at a reduced rate of ten percent[43] and withheld by the CREs where they make such distributions.

Both institutional and individual investors are liable to stamp tax at the rate of 0.1 percent of the value of share trading.

Appendix 2 [Available from Authors on Request]: Important Changes in China's Real Estate Tax Policies 2005-2007

A.2.1 A Chronology of Nationwide Changes in Tax Policy

-1 April 2005 Implementation of 5% business tax on residential property sold within two years;
-1 June 2005 deed tax (based on sale price or market value if sale price is significantly below estimated market value, and charged upon the transaction of property) maintained at 1.5% for ordinary housing but raised to 3% for non-ordinary units;

[39] It was promulgated on 13 December 1993.
[40] Article 5(5) of Interim Regulations of PRC on Business Tax, 13 December 1993.
[41] Source: MoF and SAT, *Cai Shui* (Revenue&Tax) [2002] no.75, 2002.
[42] Source: MoF and SAT, *Cai Shui* (Revenue&Tax) [2005] no.155, 1 December 2005.
[43] Source: MoF and SAT, *Cai Shui* (Revenue&Tax) [2005] no.102, 13 June 2005, and [2005] no.107, 24 June 2005.

-1 June 2006 Residential units sold within five years of purchase are subject to a 5% business tax on the selling price of properties. Ordinary housings sold after five years of purchase may get an exemption but the non-ordinary housings will still be subject to 5% business tax;
-26 July 2006 Tax authority reiterated that the 20% income tax on sale of properties will be enforced from 1 August 2006, but it could be exempt if: 1) the property has been held for more than five years and is the sellers' sole residence; 2) the seller will get partial or full tax refund if another property is purchased within one year of disposal, depending on the values of the two properties.
-16 January 2007 Full enforcement of LAT (land appreciation tax) charge on developers, effective from 1 February 2007.

A.2.1.2. Deductible items

1. The sum paid for the acquisition of land use rights;
2. Costs and expenses for the development of land and construction of new buildings and facilities;
3. The selling, administration and finance costs related to development of land and construction of buildings;
4. The taxes related to the transfer of real estate;
5. 20% of the sum of 1 and 2 above.

A.2.1.3. Tax rate

1. For that part of the appreciation, amount not exceeding 50% of the sum of deductible items, the tax rate shall be 30%.
2. For that part of the appreciation amount exceeding 50%, but not exceeding 100%, of the sum of deductible items, the tax rate shall be 40%.
3. For that part of the appreciation, amount exceeding 100%, but not exceeding 200%, of the sum of deductible items, the tax rate shall be 50%.
4. For that part of the appreciation, amount exceeding 200% of the sum of deductible items, the tax rate shall be 60%.

A.2.1.4. Exemptions

1. Tax payers constructing ordinary standard residences for sale, where the appreciation amount does not exceed 20% of the sum of deductible items;
2. Real estate taken over and repossessed according to laws due to the construction requirements of the State.

A.2.2. A Chronology of Changes in Tax Policy in Shenzhen
-1 November 2005 Education surcharge was restored at the rate of 3% of paid business tax.

A land use fee rather than a land use tax is applied in Shenzhen. The rates depend on land use fee type, land type and land class.[44]

[44] One of the co-authors, Yong Chen, has detailed tables of both land use fees and land use taxes in Shenzhen. Translation into English may be necessary as part of this project.

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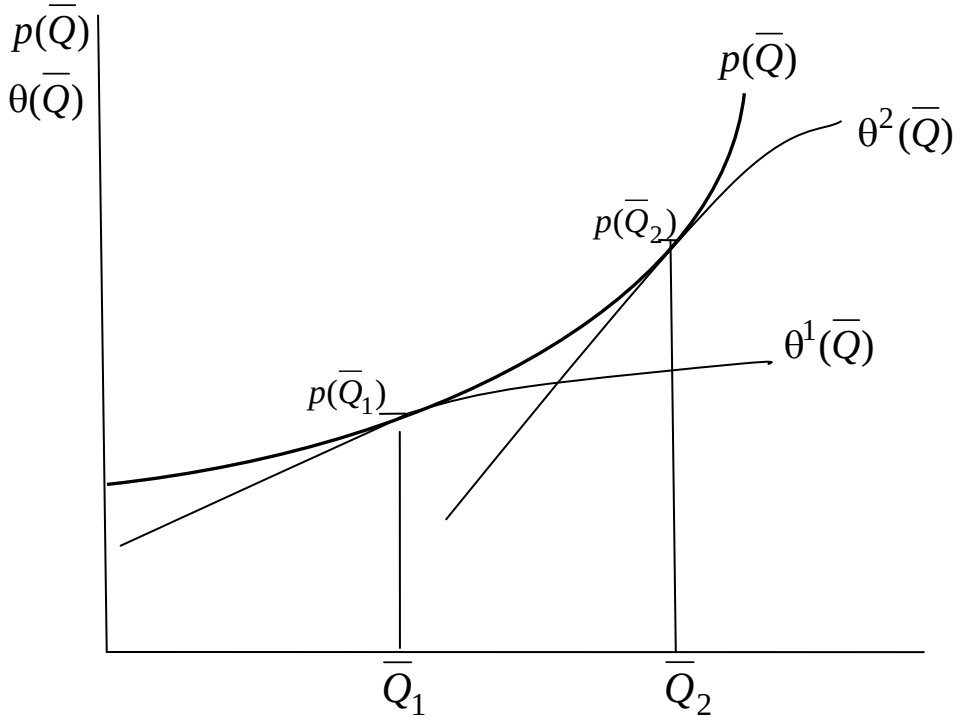
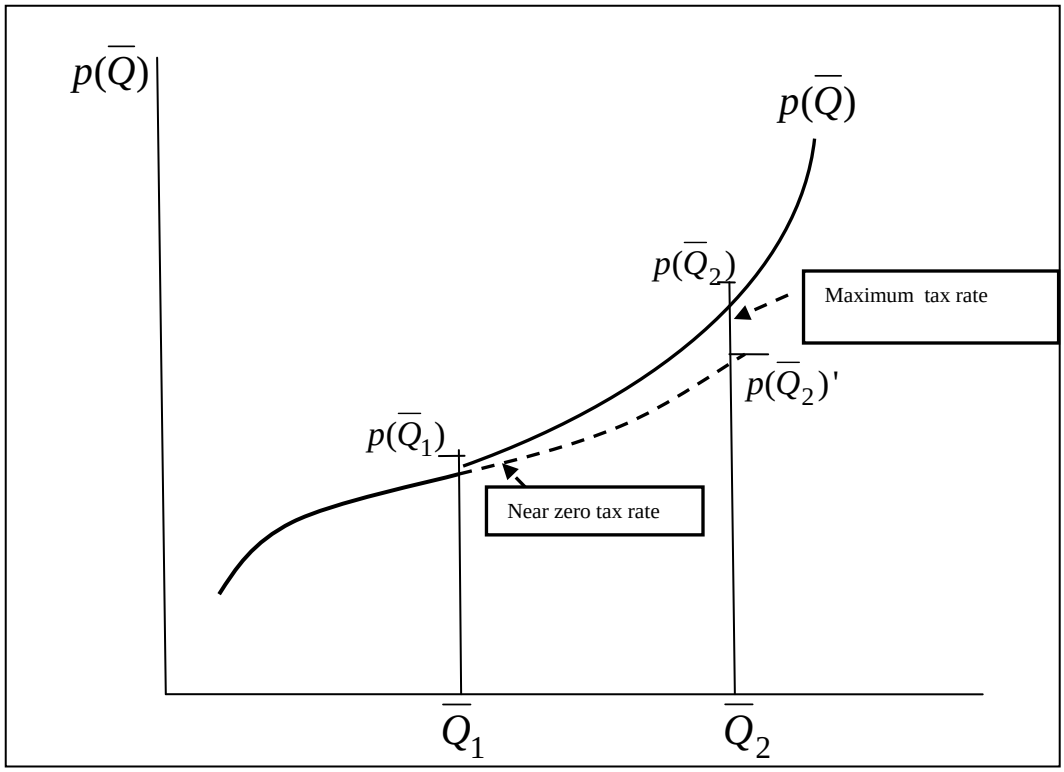
Figure 1. Convex Hedonic Equilibrium



Notes: $\overline{Q}_i$ is the interior area (square meters) of individual dwelling *i*, *size* for the purposes of empirical estimates. $\theta^i(\overline{Q})$ is the consumer *i*'s bid function, compensated for the income effects associated with changes in $\overline{Q}_i$. The hedonic value function, p($\overline{Q}_i$) is convex to the quantity axis. The $\overline{Q}_i$ are inelastically supplied. Notation for the fixed resource, L, is suppressed.

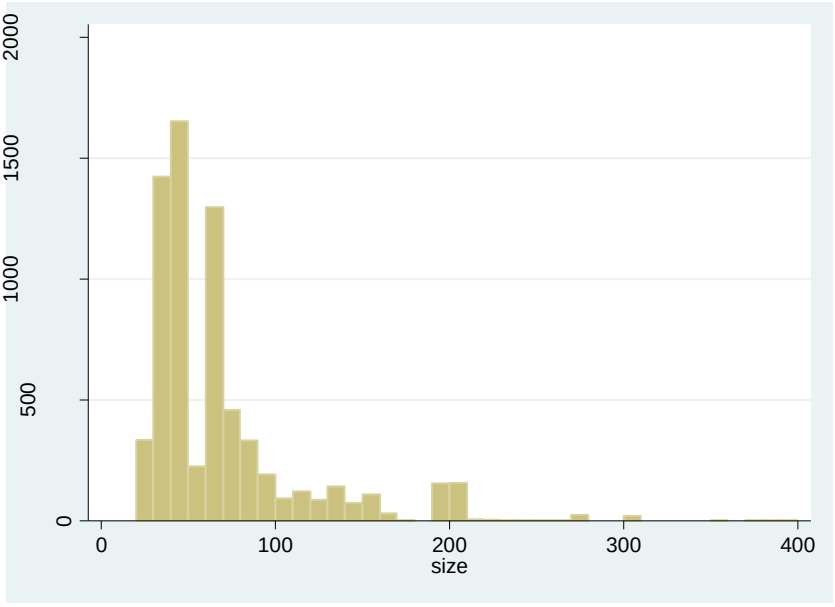
Figure 2. Hedonic pricing function after imposition of a progressive property tax



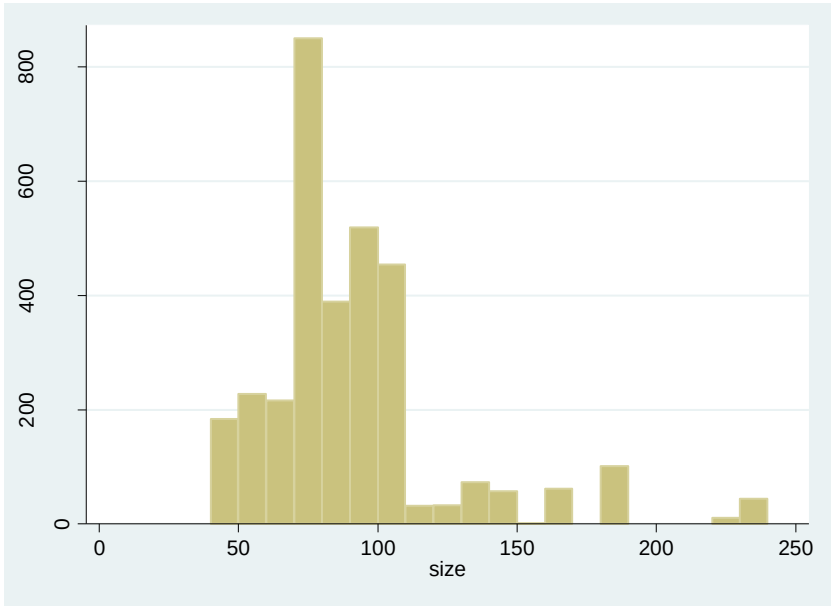
Notes: $\overline{Q}_i$ is the interior area (square meters) of individual dwelling *i*, *size* for the purposes of empirical estimates. The hedonic value function, p($\overline{Q}_i$) is first concave and then convex to the quantity axis. The $\overline{Q}_i$ are inelastically supplied. Notation for the fixed resource, L, is suppressed. The dashed line is the hedonic envelope function after a property tax that increases with $\overline{Q}_i$. The new equilibrium price for large units is $p(\overline{Q}_2)'$. Note that the tax is designed not to have any effect for quantities $\leq \overline{Q}_1$ and that the tax is imposed at the inflection point where the hedonic pricing function changes from concave to convex. Tax rates are not shown: the purpose of the arrows is to indicate the part of the hedonic function where the proposed tax will be near zero and the part where the tax rate will reach a maximum.

Figure 3. The distribution of size (square meters of interior space) in the two districts

a. Futian



b. Longgang



Notes: The star just above the border with Hong Kong indicates Shenzhen's central business district (CBD) and municipal government center. Darker shading indicates more intensively developed areas. The underlined district near the CBD is the Futian District, one of the two used for this study. The other district, Longgang is on the right hand side of the map (see underlining). The dashed line near the middle of the map gives the boundary of Shenzhen's special economic zone (SEZ).

Table 1- Panel A: The sub-sample for transactions in the Futian District.

Variable	Mean	Std. Dev.	Maximum	Minimum
Totprice	670,937	821,978	11,706,208	68,409
Lnprice	13.144	0.617	16.276	11.130
Size	68.996	46.424	391.470	27.490
Lnsize	4.079	0.517	5.970	3.310
lnsize2	16.906	4.478	35.640	10.980
lnsize3	71.272	29.613	212.766	36.390
F1	0.189	0.391	1	0
F2	0.416	0.493	1	0
F3	0.052	0.222	1	0
F4	0.090	0.286	1	0
F5	0.012	0.108	1	0
F6	0.005	0.069	1	0
F7	0.003	0.052	1	0
F8	0.125	0.330	1	0
F9	0.066	0.248	1	0
F10	0.038	0.192	1	0
F11	0.005	0.072	1	0
floor1	0.064	0.246	1	0
floor2	0.175	0.380	1	0
floor3	0.182	0.386	1	0
floor4	0.176	0.381	1	0
floor5	0.170	0.376	1	0
floor6	0.149	0.357	1	0
floor7	0.083	0.276	1	0
type1	0.475	0.499	1	0
type2	0.298	0.457	1	0
type3	0.151	0.359	1	0
type4	0.064	0.245	1	0
type5	0.011	0.107	1	0
Month4	0.007	0.085	1	0
Month5	0.007	0.083	1	0
Month6	0.062	0.242	1	0
Month7	0.121	0.326	1	0
Month8	0.087	0.282	1	0
Month9	0.128	0.334	1	0
Month10	0.051	0.219	1	0

Month11	0.059	0.236	1	0
Month12	0.064	0.245	1	0
Month13	0.081	0.273	1	0
Month14	0.059	0.236	1	0
Month15	0.078	0.269	1	0
Month16	0.127	0.333	1	0
Month17	0.069	0.251	1	0

Minimum numbers not indicated in this table are all zero. Our sample runs between August 2004 and January 2006 and has 10,252 observations inside and outside of the special economic zone (SEZ). The Futian District is inside SEZ. We have a total of 6,998 observations. Excluding the 25 transactions to produce reliable price index estimate for January 2006 reduces the size of the sample to 6,973. There were no observations for this sub-sample during August, September and October 2004. Type1 (Type5) is made up of 1-bedroom or single apartment or single dormitory (duplex and more-than-4-bedroom) properties, respectively.

Table 1- Panel B: The sub-sample for transactions in the Longgang District.

Variable	Mean	Std Dev	Maximum	Minimum
Totprice	549,365	487,068	3,946,517	144,812
lnprice	13.02	0.55	15.19	11.88
Size	90.67	34.74	234.94	42.46
lnsize	4.45	0.34	5.46	3.75
lnsize2	19.89	3.07	29.80	14.05
lnsize3	89.47	21.05	162.71	52.67
L1	0.277	0.448	1	0
L2	0.065	0.249	1	0
L3	0.274	0.446	1	0
L4	0.329	0.470	1	0
L5	0.054	0.227	1	0
floor1	0.397	0.489	1	0
floor2	0.223	0.416	1	0
floor3	0.162	0.368	1	0
floor4	0.121	0.326	1	0
floor5	0.065	0.246	1	0
floor6	0.033	0.178	1	0
type1	0.098	0.298	1	0
type2	0.358	0.479	1	0
type3	0.417	0.493	1	0
type4	0.045	0.208	1	0
type5	0.082	0.274	1	0
Month1	0.065	0.247	1	0
Month2	0.028	0.165	1	0
Month3	0.033	0.178	1	0
Month4	0.035	0.183	1	0
Month5	0.044	0.206	1	0
Month6	0.036	0.187	1	0
Month7	0.015	0.123	1	0
Month8	0.038	0.192	1	0
Month9	0.009	0.096	1	0
Month10	0.006	0.074	1	0
Month11	0.008	0.091	1	0
Month12	0.039	0.193	1	0
Month13	0.052	0.222	1	0
Month14	0.092	0.288	1	0
Month15	0.168	0.374	1	0
Month16	0.174	0.379	1	0
Month17	0.130	0.336	1	0
Month18	0.027	0.161	1	0

Minimum numbers not indicated in this table are all zero. Our sample runs between August 2004 and January 2006 and has 10,252 observations inside and outside of the special economic zone (SEZ). The Longgang District is outside SEZ. We have a total of 3,254 observations. Type1 (Type5) is made up of 1-bedroom or single apartment or single dormitory (duplex and more-than-4-bedroom) properties, respectively. But, there were no observations of single apartment or single dormitory properties or Floor7 units in this sub-sample. Only a few observations on ‘more-than-4-bedroom’ units are in this sub-sample. Sufficient observations are present in each sample month.

Table 2 - Panel A: Empirical Results for the Futian District (inside SEZ).

Models 1 and 3 (Models 2 and 4) are cubic (linear) hedonic model specifications with and without the property type variables. The base category variables are Project F7, Floor1, Month4, and Type 2 (2-bedroom units). These are OLS results. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels. Month18 is excluded due to very limited number of observations.

Variable	Model 1 Parameter Estimate	Model 1 T Statistics	Model 2 Parameter Estimate	Model 2 t statistics	Model 3 Parameter Estimate	Model 3 t statistics	Model 4 Parameter Estimate	Model 4 t statistics
Intercept	-0.563	-0.93	8.509	216.51***	-3.228	-7.13***	8.436	278.4***
F1	0.119	6.3***	0.139	7.3***	0.112	5.92***	0.158	7.51***
F2	0.228	12.1***	0.244	12.8***	0.232	12.3***	0.256	12.2***
F3	0.066	3.44***	0.081	4.2***	0.063	3.26***	0.097	4.50***
F4	0.043	2.23**	0.063	3.3***	0.041	2.16**	0.083	3.88***
F5	0.055	2.66***	0.052	2.47**	0.052	2.47**	0.050	2.16**
F6	-0.199	-8.5***	-0.193	-8.1***	-0.201	-8.52***	-0.205	-7.79***
F8	0.004	0.21	0.005	0.28	-0.005	-0.24	0.004	0.17
F9	0.473	22.5***	0.544	26.8***	0.422	20.5***	0.598	27.4***
F10	0.116	5.9***	0.139	7.0***	0.113	5.74***	0.160	7.33***
F11	0.015	0.67	-0.027	-1.16	0.030	1.31	0.080	3.11***
Lnsize	7.826	17.8***	1.053	141.9***	9.743	30.7***	1.067	271.9***
Lnsize^2	-1.656	-15.9***	N/A	N/A	-2.118	-28.9***	N/A	N/A
Lnsize^3	0.133	16.3***	N/A	N/A	0.170	30.7***	N/A	N/A
Floor2	0.047	10.4***	0.049	10.8***	0.045	10.0***	0.048	9.65***
Floor3	0.092	20.7***	0.095	21.0***	0.091	20.2***	0.095	19.0***
Floor4	0.121	26.9***	0.124	27.1***	0.119	26.2***	0.124	24.5***
Floor5	0.160	35.1***	0.163	35.2***	0.158	34.5***	0.163	31.9***
Floor6	0.174	37.4***	0.180	38.0***	0.173	36.9***	0.183	35.0***
Floor7	0.172	33***	0.174	32.7***	0.172	32.7***	0.185	31.6***
Month5	-0.009	-0.54	-0.010	-0.59	-0.009	-0.56	0.000	0.02
Month6	0.001	0.07	0.002	0.14	-0.004	-0.33	0.010	0.71
Month7	0.001	0.11	0.003	0.24	-0.005	-0.42	0.011	0.81
Month8	0.023	1.88*	0.023	1.92*	0.018	1.48	0.030	2.22**
Month9	0.007	0.58	0.005	0.44	0.003	0.25	0.012	0.92
Month10	0.033	2.65***	0.030	2.41**	0.028	2.22**	0.038	2.75***
Month11	0.033	2.72***	0.031	2.49**	0.029	2.34**	0.038	2.77***
Month12	0.039	3.21***	0.037	2.96***	0.035	2.88***	0.044	3.25***
Month13	0.035	2.93***	0.033	2.72***	0.030	2.49**	0.040	2.97***
Month14	0.051	4.18***	0.049	3.95***	0.046	3.69***	0.056	4.10***
Month15	0.061	5.03***	0.059	4.77***	0.055	4.50***	0.064	4.73***
Month16	0.085	7.06***	0.083	6.73***	0.079	6.47***	0.087	6.39***
Month17	0.105	8.65***	0.100	8.16***	0.099	8.09***	0.106	7.81***
Type1	-0.019	-4.14***	0.007	1.61	N/A	N/A	N/A	N/A
Type3	0.000	0.09	-0.019	-4.38***	N/A	N/A	N/A	N/A
Type4	-0.007	-0.67	0.018	2.27**	N/A	N/A	N/A	N/A
Type5	0.142	6.13***	0.380	29.3***	N/A	N/A	N/A	N/A
R Square		0.983		0.983		0.983		0.979
N		6973		6973		6973		6973

Table 2 - Panel B: Empirical Results for the Longgang District (outside SEZ).

Models 1 and 3 (Models 2 and 4) are cubic (linear) hedonic model specifications with and without the property type variables. The base category variables are Project L1, Floor6, Month1, and Type 5 (more than 4-bedroom units). These are OLS results. This sub-sample has no Floor7 observations.

Variable	Model 1 Parameter Estimate	Model 1 t statistics	Model 2 Parameter Estimate	Model 2 t statistics	Model 3 Parameter Estimate	Model 3 t statistics	Model 4 Parameter Estimate	Model 4 T Statistics
Intercept	7.296	2.52***	5.782	67.3***	3.848	1.97**	6.604	133.7***
L2	-0.052	-4.98***	-0.062	-5.12***	-0.069	-6.53***	-0.144	-9.93***
L3	-0.149	-22.1***	-0.179	-24.0***	-0.161	-24.4***	-0.211	-23.3***
L4	-0.060	-3.50***	-0.064	-3.17***	-0.086	-4.94***	-0.126	-5.20***
L5	-0.142	-14.6***	-0.141	-12.4***	-0.157	-15.8***	-0.155	-11.2***
Lnsize	3.366	1.75*	1.691	83.2***	5.529	4.24***	1.452	172.5***
Lnsize^2	-0.980	-2.32**	N/A	N/A	-1.406	-4.88***	N/A	N/A
Lnsize^3	0.114	3.74***	N/A	N/A	0.140	6.65***	N/A	N/A
Floor1	-0.148	-13.6***	-0.156	-12.3***	-0.153	-13.7***	-0.143	-9.18***
Floor2	-0.088	-8.24***	-0.101	-8.10***	-0.096	-8.69***	-0.103	-6.71***
Floor3	-0.072	-6.61***	-0.077	-6.10***	-0.076	-6.84***	-0.083	-5.39***
Floor4	-0.009	-0.83	-0.006	-0.47	-0.011	-0.96	-0.023	-1.47
Floor5	-0.004	-0.33	0.007	0.56	-0.004	-0.31	-0.008	-0.51
Month2	0.014	1.24	0.021	1.53	0.0117	0.97	0.015	0.87
Month3	0.028	2.55**	0.036	2.78***	0.026	2.31**	0.049	3.08***
Month4	0.055	5.06***	0.055	4.32***	0.052	4.61***	0.078	4.99***
Month5	0.061	5.84***	0.035	2.86***	0.049	4.61***	0.065	4.44***
Month6	0.095	8.74***	0.068	5.41***	0.087	7.89***	0.076	4.98***
Month7	0.120	8.14***	0.114	6.64***	0.115	7.58***	0.117	5.58***
Month8	0.144	12.9***	0.129	10.0***	0.138	12.1***	0.112	7.13***
Month9	0.106	5.76***	0.090	4.20***	0.093	4.93***	0.059	2.25**
Month10	0.215	9.32***	0.207	7.73***	0.207	8.73***	0.165	5.04***
Month11	0.248	13.0***	0.242	10.9***	0.240	12.2***	0.209	7.69***
Month12	0.176	9.75***	0.145	6.89***	0.172	9.24***	0.123	4.78***
Month13	0.183	9.81***	0.154	7.11***	0.176	9.16***	0.150	5.64***
Month14	0.234	12.5***	0.218	9.99***	0.226	11.7***	0.201	7.52***
Month15	0.245	13.5***	0.223	10.6***	0.242	13.0***	0.228	8.84***
Month16	0.255	13.9***	0.223	10.5***	0.249	13.3***	0.228	8.75***
Month17	0.277	14.6***	0.253	11.5***	0.275	14.1***	0.271	10.0***
Month18	0.293	13.8***	0.274	11.1***	0.288	13.2***	0.271	8.95***
Type1	-0.135	-5.92***	-0.276	-10.6***	N/A	N/A	N/A	N/A
Type2	0.011	0.87	-0.237	-23.0***	N/A	N/A	N/A	N/A
Type3	-0.031	-1.91*	-0.366	-24.0***	N/A	N/A	N/A	N/A
Type4	0.023	1.12	-0.280	-13.1***	N/A	N/A	N/A	N/A
R Square		0.97		0.96		0.9701		0.94
N		3254.00		3254.00		3254.00		3254.00

Table 3: Estimates of Price Elasticity.

These results are based on the estimates of the non-linear cubic hedonic model without the type variables. The arc elasticity computations equal percent change in predicted price divided by percent change in size.

	Futian (inside SEZ)		Longgang (outside SEZ)	
size (sq meters)	Price-hat	elasticity	Price-hat	elasticity
10	38,318		66,880	
20	108,109	1.82	137,898	1.06
30	175,967	1.26	193,646	0.81
40	240,202	1.10	246,687	0.82
50	301,983	1.03	302,235	0.90
60	362,427	1.00	362,941	1.00
70	422,371	0.99	430,547	1.12
80	482,428	1.00	506,461	1.23
90	543,050	1.01	591,985	1.35
100	604,586	1.02	688,418	1.47
110	667,307	1.04	797,107	1.58
>110	1,000,961	1.04	1,195,660	1.58

Table 4: Equilibrium Tax Collections under a Progressive Property Tax

Assumed parameters of the model:								
capitalization rate	4.0%	4.0%	7.5%	7.5%	4.0%	4.0%	7.5%	7.5%
% capitalized	30.0%	90.0%	30.0%	90.0%	30.0%	90.0%	30.0%	90.0%
progressivity (max tax rate)	1.0%	1.0%	1.0%	1.0%	2.0%	2.0%	2.0%	2.0%
				Futian				
Estimated Annual Tax Collected (millions of Yuan)	49.1	42.5	50.6	47.1	91.6	83.4	97.7	83.8
				Longgang				
Estimated Annual Tax Collected (millions of Yuan)	139.6	127.4	142.4	135.9	267.0	218.4	278.4	252.4
				Two areas Combined				
Estimated Annual Tax Collected (millions of Yuan)	188.7	169.9	193.0	183.0	358.6	301.8	376.1	336.2
				Projected from two areas to all Shenzhen				
Estimated Annual Tax Collected (millions of Yuan)	421.2	379.2	430.8	408.5	800.4	673.7	839.5	750.4
Other real estate taxes (billions of RMB), 2000				**Proposed property tax collections as a % of all real estate taxes**				
6.839	6.2%	5.5%	6.3%	6.0%	11.7%	9.9%	12.3%	11.0%

Notes: The capitalization rates are based on the deposit rate (4%) and the lending rate (7.5%) in China. The percent of the tax capitalized (negatively) into value is estimated from US studies. Progressivity is under the control of taxing authorities. Projections to all Shenzhen are based on *China Census 2000* (Table7-2,p. 98-99, reference A), which shows that Futian (Longgang) had 20.6% (24.2%) of all Shenzhen family housing units greater than 50 square meters, and authors' own calculations.