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Journal of Housing Economics 12 (2003) 83–105

JOURNAL OF
HOUSING
ECONOMICS

www.elsevier.com/locate/jhe

A tale of two sectors: Upward mobility and the private housing market in Singapore[☆]

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Received 10 September 2002

Abstract

Our paper examines the determinants of new private residential units sold in Singapore during the 1990s. The Singapore housing market is characterized by the coexistence of a **dominant public sector and a small, growing private sector** with relatively higher quality housing. The distinguishing feature of our model is that we account for the impact of the former on the latter, and the interaction between the two. Our analysis generates three principal conclusions: first, there is a statistically significant “wealth effect” driving the sales of new private residential properties. Second, the real loan interest rates have a statistically significant negative impact on these sales. Finally, an increase in the rate of change of public housing resale prices has an important and significant positive impact on the sales of private residential units. This is due in part to mitigation of downpayment constraints of upwardly mobile households.

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[☆] An earlier version of this paper was presented to the joint international conference organized by AsRES/AREUEA at Seoul, South Korea, in July 2002. We also acknowledge the support from the Urban Redevelopment Authority of Singapore and the Fisher Center for Real Estate & Urban Economics, UC-Berkeley. We have benefited from helpful comments by three anonymous referees.

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JEL classification: H4; L33; R21; R31; R38; R52

Keywords: International real estate; Urban housing policy; Public sector; Segmented markets; Interaction between private and public sectors; Housing mobility

1. Introduction

Singapore is one of the few countries in the world that practices an integrated housing sector policy, in which planning, urban policy and government objectives define the parameters of real estate development (Phang, 2001). Housing institutions and policies have been developed systematically and comprehensively to advance social development and economic growth in Singapore. A singular feature of the residential market in Singapore is the existence of a relatively small private sector. **Almost 86% of Singaporeans live in public housing (Lum, 2002). The Government owns more than 80% of the land in Singapore, including land destined for private development.**

The interplay of public and private housing sectors in Singapore is of great relevance and significance for the study of housing in many other countries. Several emerging markets have large public housing stocks that coexist with a rapidly growing private housing sector. Government policy in these countries plays a major role in the development of housing policy through direct management, land sales, control over privatization, subsidies and housing finance instruments. In a number of transitioning economies, such as Russia, privatization of the original stock, which was practically all government owned, has created a similar vertically segmented market, where this bottom rung of the property ladder is a launching pad for moving into new, privately constructed housing. **In China, the bottom rung of the ladder (public housing, subsidized either by local authorities or state enterprises) is largely controlled by Public policy, while the upper segment (private housing) is subject to the vagaries of the market.**

The main focus of this study is to examine the determinants of new private residential sales in Singapore. Private sector housing in Singapore cannot be understood without taking into account public sector behavior. Therefore, we develop and estimate a model for the determinants of new private residential units in Singapore with explicit tracking of the public-private linkage.¹ The private residential market caters mainly to upwardly mobile local households, those who do not qualify for public homeownership and expatriates. Although the two sectors have been relatively segmented in the past, a series of public policy measures, including deregulation of the public housing sector that began in the late 1980s, has engendered increasing integration.² This implies that any change in Government policy that has an impact on the stock of public housing, its quality, affordability or price is likely to affect

¹ Prior Singapore housing market research is overwhelmingly qualitative. Structural models and formal econometric analyses of housing market behavior are relatively scarce (Lum, 2002). While data limitations pose some problems, **a major omission of the Singapore housing literature is an explicit recognition of the linkages between the public and private housing sectors.**

² Appendix A provides some details on these policies.

the private housing sector. The small size and novelty of the private residential market allow us to treat it as a thin and embryonic market that elicits signals from the quasi-private, public housing resale market.

An authorized public housing resale market has existed in Singapore since 1971 (Phang and Wong, 1997). In the 1990s, liberalization coupled with excess demand for housing gave a further boost to this market. Since public units were allocated at subsidized rates, but could be re-sold at higher market-determined prices, ownership of public housing became a source of “fortuitous” wealth (Lum, 1996). Many “upgraders” who filtered up from public housing to better quality private housing relied on tax-free capital gains to fund a substantial part of the purchase (Ong, 1999). Factors that typically determine private housing market activity in other countries appeared to have played a far less significant role compared to public housing policy changes in Singapore (Phang and Wong, 1997).

The Housing and Development Board (HDB), formed in 1960, is the custodian of all public housing in Singapore. There are two main channels through which activities of the HDB may affect the private market. First, public housing is rationed directly by the state using non-price criteria. This implies that public housing stock may compete with and reduce the number of private units needed to accommodate households. Second, capital gains from resale of HDB units may be an important determinant of upgrading mobility.

Despite evidence of price discovery between the public and private housing sectors (Ong and Sing, 2002), standard explanations of private housing market behavior in Singapore invariably focus on macroeconomic demand-side variables (for instance, Ho and Cuervo, 2000). In an official study, private house prices have been modeled exclusively as a function of national income (The Economics Division, Ministry of Trade and Industry, 2001). Other fundamentals, such as interest rates and stock prices, were not found to impact property prices significantly, even in the short run. However, economists are now beginning to add policy variables to their models of Singapore private housing market behavior (Lum, 2002).

The remainder of the paper is organized into three subsequent sections. In the following section, we briefly discuss the evolution of the housing market in Singapore with emphasis on the gradual integration of the public and private housing sectors.³ Section 3 deals with some important theoretical issues. Section 4, the heart of the paper, describes our data, outlines the empirical model and shows the statistical results. The final section is a brief conclusion.

2. The Singapore housing market

Historically, the Singapore private sector housing market has catered to those groups that were not eligible to buy subsidized housing from the government, generally the top decile income group in Singapore, including affluent Singaporeans,

³ A brief history of the public housing sector and the eligibility criteria are discussed in Appendices A and B.

foreign investors, and the expatriate community (Lum, 2002). On the supply side, private developers constructed bungalows, semi-detached houses, and terraced houses mainly for the rich.

The residential property market has undergone a fundamental change in the last two decades. The increasing affluence and higher aspirations of Singaporeans have generated a demand for housing of better quality and greater variety. During the early 1980s the Government recognized that with increasing economic affluence, the proportion of high-income families who wanted to own private housing exceeded the measure of land supplied to private developers. Consequently, the Government scaled back the HDB's target of housing 90% of the population in public housing to 75%, leaving the rest to buy private properties. To achieve this goal the state began selling 99-year land leaseholds to private developers to build high-rise condominiums (Chua, 2000).

At the same time, rapid asset price inflation meant that many of the households who wanted to own private property could not afford to do so. These households were also too rich to qualify for public housing, thus creating a sandwiched class of residents (Lum, 1997). In an effort to bridge the gap between public and private sectors, the HDB initiated a program called the executive condominium (EC) Housing Scheme. Introduced in 1995, the EC are strata-titled apartments built and sold by private developers, with design, facilities and finishes comparable to private condominiums. They are different from wholly privatized condominiums because only applicants who meet the basic HDB eligibility criteria (but with household income ceiling of S\$11,000/month) can buy an EC unit. Owners have to occupy the units for the first five years before considering resale.

In the 1990s, many of the institutional barriers that had kept the public and private sectors separate have been gradually removed.⁴ The government has been relaxing the HDB's strict eligibility rules. While private housing owners were previously excluded entirely from the HDB market, it is now possible under certain conditions for private owners to participate in the secondary HDB resale market. In addition, it has been possible since late 1991 for HDB flat owners who have owned and stayed in their flats for at least five years to use their excess Central Provident Fund (CPF)⁵ savings for investment in private residential properties.

⁴ The Singapore Government has devised several policies to facilitate provision of private housing (see Tan, 2000). The first method used was to convert the leases of some existing semi-public housing units into private titles. These units were developed by the Housing and Urban Development Corporation (HUDC), incorporated as a private company in 1974 to provide housing for those whose total household incomes exceeded the income ceiling for HDB flats but who were unable to afford private estates. The HUDC was dissolved in 1982 and its units were transferred to the HDB. See HDB website (Housing & Development Board website at www.hdb.gov.sg, Phang, 2000 and Lum, 1997). The second program, as mentioned in the text is the EC Scheme.

⁵ The Central Provident Fund (CPF) was established in 1955 to provide financial security for workers' retirement. Over the years, it has evolved into a comprehensive social security savings program jointly supported by employees, employers and the Government. Until recently, employees and their employers contributed 20% of gross wages to the Fund for workers up to 55 years of age. The CPF enables easy home-ownership through two popular financing Schemes—The Public Housing Scheme for HDB flats and the Residential Properties Scheme for all housing properties built on freehold land or with a lease of at least 60 years remaining.

The residential property market in Singapore can be viewed as a pyramid with the largest stratum encompassing households owning and living in low-end public housing. Above that, in ascending order are the larger and newer public units, executive condominiums, entry-level private housing, medium level private housing and finally, luxury units, and landed properties. There is a possibility of direct competition and thus overlap between 5-room HDB flats, EC units and entry-level private apartments and condominiums. Generally, it has been seen that there is comovement of prices in the different residential strata and segmented markets.

The story of the Singapore housing market cannot be complete without any mention of the housing finance system. The government is the major provider of housing finance for the public housing sector with commercial banks catering to the needs of the richer households and their purchases of private housing. The major source of housing finance for the public sector is the Central Provident Fund, as mentioned above. These mandatory savings may be withdrawn at the age of 55 or earlier, for various approved purposes. Home buyers can withdraw money from their CPF accounts to make downpayments, mortgage payments, stamp duties, and interest payments incurred for the purchase of public housing as well as mortgage payments for the purchase of private dwellings.⁶ The HDB also provides subsidized mortgage financing to its flat buyers.⁷ The loan to value ratio is between 80 and 90% for a new flat and the maximum repayment time is 25 years. The HDB mortgage interest rate is pegged at 0.1% above the CPF interest rate, which has generally been 2% below the housing loan rates of commercial banks. During the past decade, rules governing the use of CPF savings have gradually been liberalized so that the resources can be used for a variety of other purposes (Phang and Wong, 1997; Tu, 1999; Zhu et al., 2002).

In many respects, the Hong Kong housing market is similar to that in Singapore. It is characterized by a sizeable public sector that currently houses half its residents, and a dynamic private sector market. Under the Housing Ownership Scheme (HOS) introduced in 1978, the Hong Kong government began providing both subsidized flats and loans for low and medium income groups whereas the private housing market served higher income households. HOS units were intended to bridge the gap between publicly provided rental housing for the poor and expensive private housing. Within this residential pyramid, trading-up could be facilitated and HOS flats were sought after as an affordable initial step to home-ownership.

Beginning in 1997, the policy stance became one of encouraging a higher degree of home-ownership (70% by 2007). As in Singapore, the idea was to motivate this through upgrading. At the lowest level, rental tenants were encouraged to purchase

⁶ The CPF Act was amended in 1981 to allow withdrawal for private home purchases.

⁷ The Government provides the HDB with mortgage finance loans. The HDB repays the loan to the Government at the prevailing CPF interest rate, while using it to provide housing mortgages to homebuyers, charging them 0.1% above the CPF rate.

their rental units at highly subsidized prices and with the aid of favorable financing. They were also given priority in the purchase of HOS units. In the HOS segment, the government liberalized transfer rules. After 3 years of occupancy, a HOS owner could resell his unit to anyone eligible for public housing at a market rate without state intervention. After 5 years of occupancy (reduced from 10 years), the occupant could resell to any party but if the party was ineligible for public housing, the state exacted a premium to cover the land subsidy.

Upward mobility on the basis of capital gains from the sale of publicly subsidized housing is therefore somewhat tempered in Hong Kong compared to the situation in Singapore. Over time, the widening overlap between HOS and private developments in terms of housing quality and pricing has placed subsidized HOS units in direct competition with private housing in the middle-income segment of the market. To a large extent, this was the result of public housing reform that did not properly account for the potential interactions between the publicly controlled and private housing sectors (Chow et al., 2002; Fu, 1995; Ho, 2002; Wong, 2002).

3. Theoretical issues

Our empirical framework benefits from theoretical literature, most recent, dealing with credit constraints, generational mobility, property ladders and the impact of downpayment mitigation, and effects of income shocks on property cycles.

Since our objective is to analyze the transactions in the upper segment of the property ladder and the impact on them of trends in the public housing market (which is a starter market for most people), Ortalo-Magne and Rady (2002) is a major theoretical resource. Ortalo-Magne and Rady describe a dynamic model of housing market fluctuations involving mortgage lending that is restricted by downpayment constraints. The two sets of actors here are younger, credit-constrained households going in for the starter housing and older, richer households. A third group of households are those who own a starter home, but are eager to accumulate wealth and move up into a more expensive home. In this model, with a positive income shock, property prices rise as well, and in equilibrium this quicker accumulation of wealth helps in mitigation of the downpayment constraint of the upwardly mobile households. In effect, property prices on the lower rung help support prices and transactions on the upper rungs. Equation (11) from Ortalo-Magne and Rady (2002) is reproduced below. It demonstrates how the price in the upper segment Q_t^H is equal to Q_t^F , the price in the starter segment, plus the present discounted value of the stream of extra utility provided by the house (upper segment) over that provided by the flat (lower or starter segment)

$$Q_t^H = Q_t^F + Et \left[\sum_{s=0}^{\infty} (1+r)^{-s-1} u(m_{t+s}^H) \right].$$

Another feature of the model is that credit constraints not only amplify income shocks, but also affect timing of decisions in such a way that tends to explain the comovement of prices and transactions. We use the latter insight from Ortalo-Magne and Rady, as well as relying on the work of Genesove and Mayer (1997, 2001) that provides an explanation for the strong positive correlation between prices and transactions in real estate markets. They provide yet another justification for our estimation technique involving transactions as the dependent variable. Also relevant is Stein (1995), which connects the downpayment issue with price–volume correlation. Stein presents a model of trade that shows how downpayment constraints can result in explaining multiple equilibria, price volatility, as well as the price–volume correlation.

As mentioned earlier, public housing in Singapore is a starter home for many, and capital gains from sales of the starter home are channeled into the purchase of a more expensive private home. Indeed, Ortalo-Magne and Rady point out, citing a report from Chicago Title and Trust Company, that proceeds from the sales of a previous property finance 30.7–50.7% of the downpayment required in the purchase of a subsequent property in major metropolitan areas of the US. The transmission mechanism from prices in public housing to quantities transacted in the upmarket private sector, in analogy to the Ortalo-Magne and Rady scenario, is as follows: a rise in prices of public housing in the secondary market enables households to afford higher downpayments in the more expensive sector. This movement up the property ladder is accompanied by an increase in transaction volume, which is the result of higher incomes and capital gains and the surge of households toward the private market. A reverse effect is also possible. This channel is the story behind our estimation equation shown below.

4. Modeling the Singapore private housing market

4.1. Determinants of private housing activity

Our model is designed to explore the determinants for the number of *new private residential units sold*, *PRS*, defined to be the total number (flow) of new private residential units sold in the primary market by homebuilders per quarter.

The increase in private housing demand, particularly during the early 1990s, may be explained at least in part by the existence of a “bubble” in both the property and stock markets. According to this view, changes in expectations coupled with wealth effects from public housing sales and equity stock appreciation fuelled purchases of new, relatively higher quality, private sector housing units.

Economic and demographic fundamentals are the second set of determinants of new private housing transactions. Singapore experienced rapid economic growth during the earlier part of the 1990s, but the pace of GDP expansion decelerated after the 1997 Asian Financial Crisis. In essence, strong economic growth during the early 1990s led to increased levels of per capita income and wealth as well as positive expectations about future growth, which in turn,

created an increased demand for higher quality private market housing. User costs are also critical in determining housing consumption behavior. At the aggregate level, the main components of user cost are the level of mortgage rates, which have remained low during the 1990s, and the expected rate of house price appreciation, which has been relatively high for a substantial portion of the 1990s. Simultaneously, Singapore's population has been boosted by immigration-friendly policies, favoring high-income earners. One in four of the resident population is a foreigner.

The third determinant for new private housing activity stems from the increasing integration between the previously segmented private and public housing sectors. In an effort to reduce the long queues for subsidized new public housing units during the late 1980s and early 1990s, the Government began to liberalize the public housing secondary market. This generated unanticipated capital gains for sellers of HDB units. Many deployed sizeable gains for upgrading into private market units.

As mentioned before, the private residential market is thin and volatile.⁸ For this reason, as well as due to insights from Stein (1995) and Genesove and Mayer (1997, 2001), we deem it appropriate to adopt an approach involving quantities transacted in the private sector. In addition, Telmer and Zin (2002) show that in incomplete markets, some asset prices can be proxied by other asset prices. The vast, established public market together with its substantial resale sub-market provides both a down-payment mitigating factor for those upgrading from the public to the private sector, as well as signals for transactions in the private sector, since the latter's own price might not reflect the relative scarcities, i.e., parties transacting in the private market take into account price dynamics in the public resale market. Our reliance on the level of public sector housing prices as a key determinant of the number of transactions in the private sector is not total. Our modeling approach captures both the signaling effect of the public sector and the interactive impacts of the public and private sector.

4.2. Data

Most of our data has been obtained from the **Urban Redevelopment Authority (URA) of Singapore**. Our main variable of concern, PRS, the number of new housing units sold by the private sector each quarter, is a flow variable. The URA has also provided the home loan rate data (HLR), the public housing sector resale price (HDBRE) as well as the private sector housing price (PSHP) indices. The data for GDP and the Singapore Straits Time Index (STI) have been obtained from the official Singapore Statistical website: www.singstat.gov.sg and DataStream, respectively. Table 1 and Fig. 1 depict the dependent variable, PRS. Fig. 2 shows the movements of key exogenous variables.⁹

⁸ See Hess (1972) for a relative definition of thin markets and the implication that embryonic, new, thin markets exhibit high variances in prices that differ from the true equilibrium price.

⁹ Real Gross Domestic Product is in 1997–1998 Dollars. Singapore STI and home loan rate are shown in nominal terms.

Table 1
Summary statistics of PRS (1990–2001, quantity)

Variable	Mean	Median	SD
PRS (w/o EC)	1627.94	1408.00	825.79
PRS (w/EC)	1787.08	1715.50	846.17

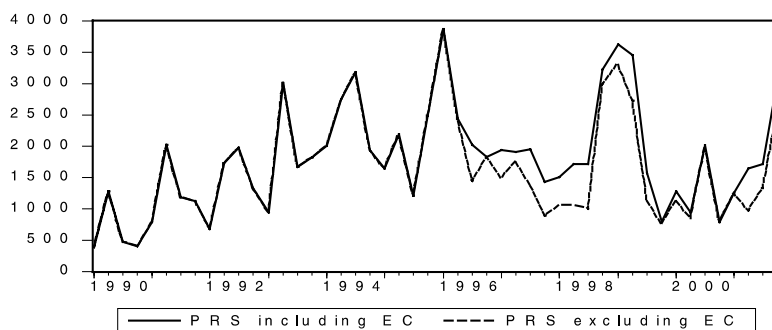


Fig. 1. PRS with and without executive condominiums.

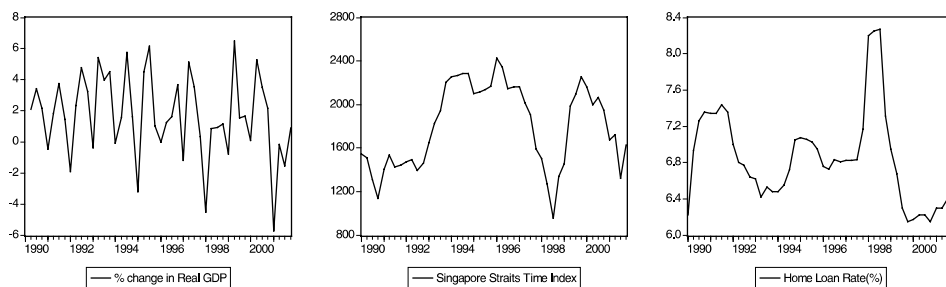


Fig. 2. Key exogenous variables.

4.3. Empirical model

Our model for the determinants of new private residential units sold is given by the following equation:

$$PRS_t = \beta_0 + \% \Delta X_t \beta_1 + I_t \beta_2 + D_t \beta_3 + \mu_t, \quad (1)$$

where $\% \Delta X_t$ is the vector of variables expressed as percentage change; at quarter t ; I_t , an interaction variable between the public and private housing markets (explained later); D_t , set of time dummy variables; μ_t , the random error term; and β_i , regression coefficients to be estimated.

PRS is the number of new private units sold to the public per quarter. Our X vector contains four variables. They are the percentage changes in the following

variables: real Singapore Stock Index (STI), populations, both native and foreign residents, real GDP, and the level of the real home loan rate.¹⁰ To determine how the public housing market influences the number of new private housing units, we use two variables—the % change in the HDB (public) resale price index as well as an interaction variable, I_t :

$$I_t = \% \text{ change in HDB Resale Price Index} \times \frac{\text{HDB Resale Price Index}}{\text{PSHP}},$$

where PSHP is the private property price index (Base year 1990 = 100 for both PSHP and the HDB Resale Price Index).

Finally, we employ time dummies to capture effects of the Singapore Anti-Speculation Package and the Asian Financial Crisis.

4.4. Statistical modeling issues and the MARMA approach

The estimation of Eq. (1) poses a variety of thorny econometric issues. Autocorrelation may exist in some exogenous variables because they are slow moving stocks (e.g., population, number of units, etc.). Another problem may stem from the omission of many potentially important exogenous variables that capture the unique aspects of the sub-markets in Singapore. There is latent simultaneity between private and public housing activities, an issue that we address in the course of the empirical work through instrumental variables. The sparse time series sample limits our ability to examine the dynamic properties of the model. Private housing sales—PRS, is a stationary variable, but the fundamental independent variables are not. We therefore include the independent variables in a percentage change format, wherein they are all stationary.

We estimate Eq. (1) using a multivariate autoregressive moving-averages (MARMA) model with and without instrumental variables. A MARMA model relates the dependent variable to its lagged values, current and lagged values of one or more independent variables, and an error term, which is partially explained by a time-series model.¹¹ The rationale for using MARMA boils down to the following considerations: first, due to data paucity we are restricted from using cointegration analysis; second, we are dealing with stationary variables; and third, combining time-series and regression analyses typically generates better estimates than would be possible by the use of either of the techniques alone, and can accommodate different phenom-

¹⁰ To convert nominal Singapore Stock Index to real we used GDP deflator, for the other variables, we used CPI for the purpose of conversion. The GDP is in 1997–98 Dollars.

¹¹ A general MARMA (1,1) process is acceptable rather than more complicated processes requiring higher-order terms. Processes that are more involved than an MARMA (1,1) model are usually very difficult to analyze. Moreover, given the small sample size, use of higher order MARMA is not feasible. Our tests evaluated up to MARMA (4,4) terms, but none of the MARMA terms above order 1 were significant (Kennedy, 1998; Pindyck and Rubinfeld, 1998).

ena. MARMA therefore gives us a sufficiently broad, general, and yet simple tool to analyze our data. The general procedure is to form a regression model with independent variables that can explain the variations in PRS. Then we apply time-series analysis by constructing an ARMA model for the residual μ_t . We then substitute the ARMA model for the implicit error term in regression Eq. (1). As explained later, we also resort to instrumental variables estimation because of the possibility of endogeneity.

4.5. Empirical findings and discussion

Tables 2–4 contain our principal empirical findings. Table 2 consists of four statistical sub-models (columns 1, 2, 3 and 4) for estimating PRS excluding executive condominiums. Columns 1 and 3 are generated from Non-linear Least Squares (NLS), ARMA(1,1) estimators. Columns 2 and 4 are ARMA(1,1) with instrumental variables estimators. Table 3 is a replication of Table 2, except that the dependent variable, PRS, includes executive condominiums (EC). Table 4 provides various point estimates for measuring the impact of changes in the public housing prices upon PRS activity levels, taking into account the public–private housing sector interaction.

In general, the statistical findings in Tables 2 and 3 are consistent with our a priori notions. First, real home loan rates (mortgage rates) are a key determinant of

Table 2
Determinants of PRS (Dependent variable: new private units transacted (PRS) excluding executive condominiums.)

Variable	Column 1	Column 2	Column 3	Column 4
Constant	2286.646** (11.705)	2283.836** (11.332)	2212.838** (11.214)	2173.130** (9.427)
GDP	-22.174 (-1.429)	-8.840 (-0.494)	-18.353 (-1.317)	-15.013 (-0.521)
Real Singapore stock index	16.176** (3.174)	13.515** (2.319)	13.386** (2.857)	11.538* (1.985)
Real home loan rate	-133.532** (-9.552)	-126.443** (-5.997)	-141.339** (-11.267)	-150.873** (-5.926)
Public resale prices	59.192** (3.311)	33.124* (1.718)	341.983** (3.014)	471.306** (2.361)
Interaction term	—	—	-253.042** (-2.491)	-365.395** (-2.121)
R ²	0.58	0.56	0.63	0.60
Adjusted—R ²	0.51	0.48	0.57	0.52
SE of regression	570.89	589.88	536.34	565.17

Terms in parenthesis are *t* statistics.

All the regressors are expressed in percentage changes except the real home loan rate. The real home loan rate is the nominal mortgage rate adjusted for inflation.

Coefficients marked with ** and * are significant at 5% and 10% levels, respectively.

Columns 1 and 3: non-linear least square (NLS) ARMA (1,1) estimates.

Columns 2 and 4: NLS ARMA (1,1) with instrumental variables.

The interaction variable is defined as $I_t = \% \text{ change in HDB Resale Price Index} \times ((\text{HDB Resale Price Index})/\text{PSHP})$.

Table 3

Determinants of PRS (Dependent variable: new private units transacted (PRS) including executive condominiums.)

Variable	Column 1	Column 2	Column 3	Column 4
Constant	2219.139** (6.488)	2238.871** (6.542)	2221.738** (7.038)	2319.572** (7.845)
GDP	10.72 (0.316)	11.243 (0.309)	-1.118 (-0.035)	-20.308 (-0.581)
Real Singapore stock index	20.03** (3.277)	15.919** (2.283)	17.686** (3.272)	13.093** (2.301)
Real home loan rate	-90.765** (-2.398)	-100.018** (-2.462)	-112.153** (-3.300)	-137.246** (-4.051)
Public resale prices	42.556** (2.197)	41.474 (1.388)	362.57** (2.625)	371.516* (1.813)
Interaction term	—	—	-289.352** (-2.324)	-286.987 (-1.614)
R^2	0.47	0.47	0.54	0.56
Adjusted— R^2	0.39	0.375	0.45	0.476
SE of regression	653.30	652.99	616.618	597.63

Terms in parenthesis are t statistics.

All the regressors are expressed in percentage changes except the real home loan rate. The real home loan rate is the nominal mortgage rate adjusted for inflation.

Coefficients marked with ** and * are significant at 5% and 10% levels, respectively

Columns 1 and 3: non-linear least square (NLS) ARMA estimates.

Columns 2 and 4: NLS ARMA (1,1) with instrumental variables.

The interaction variable is defined as $I_t = \% \text{ change in HDB Resale Price Index} \times ((\text{HDB Resale Price Index})/\text{PSHP})$.

new private housing activity and, as expected, the sign of the coefficient for the real mortgage rate variable is negative. Second, the estimated coefficient for stock equity wealth has a statistically significant positive impact on the number of new private housing units in Singapore. Third, for Singapore, changes in the public housing market are critical for explaining changes in private housing market behavior; the implication of the coefficient on the interaction variable is explained below (see Table 4). These findings are robust across model specifications and estimation techniques. GDP and demographic variables, such as foreign and resident population (omitted in regressions presented in Tables 2 and 3) tend to be not statistically significant.

The results regarding GDP need some elaboration. While intriguing at first sight, it is perhaps not very surprising that GDP was found not to have a significant impact on private residential sales. The reasons could plausibly be one or more of the following. First, the limited nature of the data series that we possess, implying that a longer series and a cointegration approach may have discovered that kind of long run relationship; i.e., changes in current GDP over the short horizon may not reflect permanent income change as well as our wealth variable does. Second, our dependent variable is a “quantity” variable and not a “value” variable. It is the latter that is more likely to be affected by changes in current GDP. The former is more a reflection of long-run demographics. For instance, in a general equilibrium model, with a

Table 4

The effect of a percentage change in public resale prices on the quantity of new private units sold (PRS)

Net effect of 1% increase in public resale prices on the quantity of new private units sold Mean of the ratio ^a = 1.186 SD = 0.248	Results from Table 2 coefficients		Results from Table 3 coefficients	
	Column 3	Column 4	Column 3	Column 4
At the mean	41.875	37.947	19.40	31.15
At the mean -1 (SD)	104.629	128.565	91.16	102.32
At the mean +1 (SD)	-20.88	-52.67	-52.36	-40.02

^aThe ratio is defined as (HDB Resale Price Index/PSHP).

static population and rising incomes, the number of housing units may be constant, but house values could be rising.¹²

We conducted Chow breakpoint tests for the onset of the Asian financial crisis during the summer-fall of 1997, as well as for the point of introduction of the anti-speculation measures in the spring of 1996. The structural change hypothesis can be rejected statistically, although our sample size leaves us with an illusory sense of comfort. To explore the possibility of one-time changes, we use time dummies for several different quarters, such as 1996:2 and for the period from 1997:2 till 1998:1. In all cases the dummy variables were not statistically significant.

Our statistical results support the hypotheses that capital gains from the HDB secondary market, growth in stock market wealth, the real home loan rate as well as changes in expectations are significant determinants of the new private housing units transacted. Prior to the introduction of the Anti-Speculation package, appreciation from flats combined with stock market equity growth increased the mobility of housing upgraders. After the requirement of a 20% downpayment was imposed for purchases of private housing units, substantial gains created by large increases in the HDB resale market *continued* to boost PRS by jointly improving household mobility and easing downpayment constraints. This interpretation is consistent with the regression results in Table 2 (columns 1 and 2; excluding EC) and Table 3 (columns 1 and 2; including EC). Our results show that an increase in public housing resale prices has a stimulative effect on PRS. That is, an increase in public housing resale price index increases household wealth, which in turn leads to an increase in sales of new housing at the next size and/or quality level.

The likely interaction between private and public housing sectors may cause endogeneity-simultaneity bias in estimating our model. Also, since the Government in

¹² Because of concerns of collinearity we run the same regressions without GDP, as suggested by a reading of Feldstein (1973). The results, not reported, do not change in any significant way. A regression with only GDP, the stock index variable and the real lending rate as independent variables also gives a result where the coefficient on GDP is insignificant.

all likelihood looks at the transactions in the private sector to carry out its land sales policy, and hence impacts the right-hand side variables, the endogeneity issue is acute. To deal with this circumstance we employ instrumental variables. The results with instrumental variables estimation are shown in columns 2 and 4 of Tables 2 (excluding EC) and 3 (including EC). The results with executive condominiums, included as part of PRS, are marginally inferior to those that exclude EC; otherwise the two sets of statistical results are similar.

In Table 4, the impact of the interaction variable I_t on PRS is evaluated at the mean value of the ratio of public resale housing prices and private housing price indices, and also at the mean value plus and minus one standard deviation. *Ceteris paribus*, the effect of a percent change in the HDB resale price index will have a dual effect on PRS. The first effect is the direct effect of the public resale price. The second is the combined effect of the public resale price and that of relative price changes between the private and the public housing sectors. The net impact of a percentage change in the resale public prices is mostly positive for a wide range of values of the relative price ratio. At the mean value of the ratio (1.186), a one percentage change in the resale price has a combined positive impact on PRS, (i.e., the effect of 1% increase in real HDB resale price is 41.875 units per quarter (= 341.983–253.042 * 1.186) (please refer to Table 4, column 1; without instrumental variables).¹³

Evaluated at the mean minus one standard deviation of the ratio, the positive impact is even greater, whereas at mean plus one standard deviation, the impact does turn negative. Our explanation for this behavior rests on a combination of factors, such as the mobility constraints, role of expectations, and the correlation in prices between the public and private housing sectors. The increase in HDB resale prices mitigates the upward mobility constraint and boosts the number of units sold in the private market. In addition, because of speculative motivation of the buyers, a current increase in the resale prices in the public sector spills into the private sector in the form of increased prices in the latter. Adaptive expectations lead to an increase in PRS through speculative buying. In other words, buyers expect the future prices in the private sector to increase. On the other hand, if the HDB resale prices are already significantly higher than those of the private sector, any further increase may cause “regressive” expectations, fears of anti-speculative measures, lesser affordability, and hence a negative impact on the transactions of private residential units.¹⁴

¹³ $\partial(\text{PRS})/\partial(\% \text{ change in public resale price}) = \text{coefficient on public resale price} + (\text{coefficient on interaction variable} * \text{ratio of public resale prices to private sector housing prices})$.

¹⁴ This finding can be qualified on two grounds. First, we look only at the 1990s, admittedly a small dataset, and a decade of many changes. Second, our result does not hold for all values of the interaction variable. If the public resale price index is significantly higher than the private, then an increase in the former leads to the more intuitive result, i.e., the quantities transacted decrease in the private sector. Also, our dataset does not include explicit prices but rather, indices. Therefore, it is difficult to get a measure of actual magnitude of capital gains.

5. Conclusion

An understanding of the interplay of the public and private housing sectors in Singapore is potentially of great relevance for the study of housing in many other countries. A number of developing and transitioning countries, such as Russia, China, India, and a host of East European countries have large public housing projects, or at the very least a major role for government policy in housing. This public sector coexists with a growing private sector. This paper represents one of the first explicit econometric analyses that traces and evaluates the impact of the linkages between the public housing sector, dominated by public policy, and the competitive private housing market. A major omission of housing literature is an explicit recognition of the linkages between the public and private housing sectors. Our approach, in contrast, explicitly models the linkage between the public and the private housing markets. A public–private sector interaction variable is utilized to capture upgrading mobility, changes in the linked housing markets, and household expectations.

The results of our study are economically meaningful and statistically robust across specifications. Our statistical analysis generates three principal conclusions. First, there is a significant positive financial wealth effect driving the amount of new private sector housing sales. Second, the real lending rate has a statistically significant negative impact on new private housing transactions. Third, an increase in the rate of change of public housing resale prices has a significant impact (directly and indirectly through our interaction modeling variable) upon the sale of private residential units, due at least in part to the mitigation of the downpayment constraints of upwardly mobile households. Surprisingly, changes in GDP do not have statistically significant effects on private residential activity. This may be true in part because changes in current GDP do not necessarily reflect changes in permanent income and/or our wealth measures may be better measures of permanent income.

These findings support and are consistent with the hypotheses that growth in wealth, as well as capital gains in the public sector, generate upward mobility of households into the higher quality private housing sector, and also create expectations about the private housing market that are positive or negative, depending upon the relative price levels in the two sectors.

Appendix A. A brief history of the public housing market in Singapore and recent policy changes

A.1. The public sector

The public housing program in Singapore can be traced back to 1927 when the colonial government founded the Singapore Investment Trust (SIT). During its 32 years of existence SIT built only 22,115 housing units (HDB, 1997). Consequently, at the time of internal self-government, rapid growth in population, and policy neglect resulted in deplorable housing conditions.

The People’s Action Party (PAP) government that came to power in 1959 made housing a priority of public policy. Through the Housing and Development Act, passed in 1960, the national public housing authority, the **Housing and Development Board (HDB)**, was established as a statutory board (Phang, 2001). As an autonomous agency, the HDB operates financially and administratively as if it were a private corporation that freely enters into contractual relations with other entities. It was also entrusted with all development processes, from land clearance and resettlement to planning and designs of flats, as well as allocation and maintenance of the properties.

Even today, the Singapore housing market is overwhelmingly dominated by the public sector. Currently, about 86% of Singapore’s 4 million people live in public housing developed by the HDB, of which, **around 90% own the residence in which they live through a 99-year lease officially called the “home-ownership scheme” started in 1964.** The political and economic motivations are well understood in the words of the then Prime Minister Lee (2000) (Phang, 2000):

My primary preoccupation was to give every citizen a stake in the country and its future (p. 116)..... I believe this sense of (home) ownership was vital for our new society, which had no deep roots in a common historical experience (p. 117).

Policy changes: 1980–2001

Year	HDB policies	CPF	Others
1980			<i>Residential GLS</i> <ul style="list-style-type: none"> Quantum of 130 units released, a decrease of 328 units from 458 units released in 1979
1981	Income ceiling raised \$3500 (4/5/Exec)	<i>Approved residential properties scheme (ARPS)</i> <ul style="list-style-type: none"> 90% of members’ balance and monthly contributions in their ordinary account can be used to redeem outstanding loan on 1 private residential property (June 1981) 	<i>Residential GLS</i> <ul style="list-style-type: none"> Quantum increased by 3419–3549 units
1982	<i>Resale flats</i> <ul style="list-style-type: none"> New system of graded resale levy based on the flat types introduced (September 1982) (10% for 3 rm flats; 15% for 4 rm; 20% for 5 rm; 25% for executive, and 30% for HUDC flats). Prior to this, the levy was at a flat rate of 5% for all flat types 	<i>ARPS</i> <ul style="list-style-type: none"> 90% of members’ balance and monthly contributions in their ordinary account can be used to purchase all types of private residential properties of freehold or at least 75 years tenure 	<i>Residential GLS</i> <ul style="list-style-type: none"> GLS sites for residential development was suspended

Appendix A (continued)

Year	HDB policies	CPF	Others
1985	<p><i>New flats</i></p> <ul style="list-style-type: none"> Income ceiling revised \$4000 (All) \$6000 (HUDC) <p><i>Resale flat</i></p> <ul style="list-style-type: none"> Resale levy waived for 1st flat, (July 1985) 	<p><i>ARPS (July 1985)</i></p> <ul style="list-style-type: none"> 100% of members' balance and monthly contributions in their ordinary account can be used to purchase all types of private residential properties of freehold or at least 75 years tenure The maximum amount withdrawn cannot exceed 80% of purchase price or valuation at time of purchase whichever is lower Time bar to reuse funds for property purchases reduced to 1 year 	<p><i>Market revival measures (July 1985)</i></p> <ul style="list-style-type: none"> 30% property tax rebate 3 year deferment on the repayment of outstanding loan for GLS sites PCP for projects extended by 35% of original PCP
1986			<p><i>Market revival measures</i></p> <ul style="list-style-type: none"> 50% property tax rebates PRs can use half of their \$1m deposits which foreigners are given PR status for private housing purchases (April 1986)
1989	<p><i>Resale flats</i></p> <ul style="list-style-type: none"> PRs can buy resale flats. (September 1989) Removal of income ceiling for resale flats (September 1989) Owners who purchased flats from resale market allowed to invest in private property (September 1989) 		
1991	<ul style="list-style-type: none"> Singles above 35 years old can purchase 3 rm or smaller resale flats outside Central Area (Oct 1991) Owners of new HDB flats can invest in private property, but they must continue to reside in flat (October 1991) 		<p><i>Residential GLS</i></p> <ul style="list-style-type: none"> GLS resumed with a quantum of 2000 units
1992	<p><i>New flats</i></p> <ul style="list-style-type: none"> Income ceiling raised to \$7000 		<p><i>GLS residential</i></p> <ul style="list-style-type: none"> Quantum increased by 500 to 2500 units

Appendix A (continued)

Year	HDB policies	CPF	Others
1993	<p><i>Housing loan liberalization</i></p> <ul style="list-style-type: none"> HDB revises quantum for subsidized HDB mortgages from 80% of the posted price of the flat as at 1984 as determined by HDB to 80% of market valuation or purchase price, whichever is lower (April 1993) 	<p><i>Liberalization of ARPS</i></p> <ul style="list-style-type: none"> CPF members can make additional withdrawal to service interest payments even if the total sum withdrawn exceeds the purchase price of the private property (wef October 1993) 	<p><i>GLS residential</i></p> <ul style="list-style-type: none"> Quantum increased by 500–3000 units
1994	<p><i>New flats</i></p> <ul style="list-style-type: none"> Income ceiling raised to \$8000 From October 1994, the minimum occupancy period before HDB lessees can reapply for a new flat from HDB was raised from 18 months to 5 years <p><i>Resale flats</i></p> <ul style="list-style-type: none"> Under the graded resale levy introduced in September 1982, lessees who sell their flats in the open market can pay either a graded resale levy on their 1st flat or a standard premium on their 2nd flat purchased from HDB. The quantum of the standard premium was doubled to 20% of the selling price of the new HDB flat (October 1994) 	<p><i>CPF Housing Grant Scheme</i></p> <ul style="list-style-type: none"> \$30,000 grant for eligible 1st timers to purchase resale flats within 2 km of parents' homes (October 1994) 	<p><i>GLS residential</i></p> <ul style="list-style-type: none"> Quantum increased by 500–4000 units GLS of 99 year landed properties introduced <p><i>Other policies</i></p> <ul style="list-style-type: none"> Buyers have to pay 5% booking fees for private housing
1995	<p><i>Contra Scheme</i></p> <ul style="list-style-type: none"> HDB flat owners purchasing a resale flat allowed to offset the cash payment and shortfall against the cash proceeds pending the completion of the sale of their existing flat (June 1995) 	<p><i>CPF Housing Grant Scheme</i></p> <ul style="list-style-type: none"> All 1st timers who purchase resale flats are eligible for grants, even if they do not live near their parents. They get \$40,000 while those near parents get \$50,000 (June 1995) 	<p><i>GLS residential</i></p> <ul style="list-style-type: none"> Quantum increased by 2000–6000 units <p><i>Other policies</i></p> <ul style="list-style-type: none"> Privatization of selected HUDC estates Buyers have to pay 10% booking fees for private housing ECs were introduced in August 1995

Appendix A (continued)

Year	HDB policies	CPF	Others
1996	<p><i>New flats</i></p> <ul style="list-style-type: none"> • HDB stopped accepting applications for executive apartments 	<p><i>CPF Housing Grant Scheme</i></p> <p>Grants extended to 1st-timer applicants for executive condominiums (August 1996)</p>	<p><i>GLS residential</i></p> <ul style="list-style-type: none"> • Quantum of 6000 units for private housing remained unchanged • Sites for 2100 units of executive condominiums were released <p><i>Anti-speculation measures (May 1996)</i></p> <ul style="list-style-type: none"> • Capital gains tax introduced for <i>all</i> residential property: 100% of gains taxable if sold within 1 year 66% of gains taxable if sold within 2 years 33% of gains taxable if sold within 3 years • Stamp duty is payable by vendor (in addition to buyer) if the sale was within 3 years of purchase. Parties pay on signing of Sales & Purchase agreement instead of completion • Financing is limited to 80% of purchase price or valuation, whichever is lower (80% includes CPF but excludes grants) • Housing loans in S\$ not allowed for foreigners
1997	<p><i>Eligibility for second new HDB flats</i></p> <ul style="list-style-type: none"> • Time bar to re-apply for new HDB flats increased from 5 to 10 years to shorten queue (May 1997) • Resale levy simplified to graded resale levy only based on the sale value of the old flat. Buyers of new flats and ECs pay: 20% for 3 rms; 22.5 % for 4 rms; 25% for 5 rm & executive flats (May 1997) 		<p><i>GLS residential</i></p> <p>Quantum for private residential units was to be increased by 1000 to 7000 units. However, this was subsequently reduced to 5000 units in view of the economic situation (November 1997)</p> <p>The quantum for ECs increased from 2100 to 4000 units</p>

Appendix A (continued)

Year	HDB policies	CPF	Others
	<p><i>Housing loans tightened</i></p> <ul style="list-style-type: none"> • Each person can get a maximum of 2 subsidized housing loans (April 1997) • Age ceiling of 65 years and maximum term of 30 years (April 1997) • Maximum income of \$8000 • Non-owner of private property • Borrowers subject to credit assessment <p><i>Applicants for new HDB flats</i></p> <ul style="list-style-type: none"> • New applicants under the Fiancé Fiancée scheme required to pay \$5000 registration deposit. The deposit will be forfeited if the application is subsequently withdrawn or cancelled (June 1997) 		<ul style="list-style-type: none"> • Project completion period for projects where units have not been launched for sale was extended to 8 years subject to the payment of a premium of 5% of the land price per year of extension (November 1997) <p><i>Other policies</i></p> <ul style="list-style-type: none"> • Vendor of a private housing unit no longer needs to pay stamp duty surcharge (November 1997)
1998		<p><i>CPF housing grant</i></p> <ul style="list-style-type: none"> • Housing grants extended to singles: \$15,000 under the Single Singapore Citizen Scheme (June 1998) 	<p><i>GLS residential</i></p> <ul style="list-style-type: none"> • GLS was suspended • The 5% premium for extensions of PCP is suspended for applications for extensions of PCP made between 1 July 98 to 31 December 99 • PCP extensions can also be granted for cases where some units have been sold. However, the PCP of such projects can only be extended up to the date of vacant possession as stated in the sales and purchase agreements <p><i>Off budget measures</i></p> <ul style="list-style-type: none"> • Stamp duty payable only when the project obtains T.O.P.
1999	<p><i>Housing loans tightened</i></p> <ul style="list-style-type: none"> • Only upgraders who purchase a larger flat than their existing unit are entitled to a second subsidized housing loan (October 1999) 	<p><i>CPF housing grant</i></p> <ul style="list-style-type: none"> • Amount of grant gradually reduced to \$40,000 (near parents), \$30,000 for other resale flat buyers and \$11,000 (singles). EC 1st time buyers 	

Appendix A (continued)

Year	HDB policies	CPF	Others
2000		get \$30,000 (Grant was reduced by \$1000 per month from January to October 1999)	<i>GLS residential</i> <ul style="list-style-type: none"> • GLS resumed with a quantum of 6000 units for private residential developments and 3000 units for EC developments
2001	Wef 28 Aug 2001, single citizens aged 35 or above can buy 3 rm or smaller resale flats in any location		<i>GLS residential</i> <ul style="list-style-type: none"> • Quantum for private residential reduced to 4000 units (including ECs) • Reserve list introduced with potential supply of 2300 units

Note. Years where there was no significant property related events are not shown. Source: Various.

Appendix B*B.1. Eligibility and related criteria for public housing*

Households can either own or rent publicly provisioned apartments. New units are sold or rented at a heavy discount and the HDB has strict eligibility rules. The buyers of public housing have to be citizens or permanent residents of Singapore. Demand is also regulated by eligibility rules such as household income and non-ownership of private properties at the time of application. Only very high-income families are ineligible for public housing. Qualifying citizens who purchase a HDB flat are granted a 99-year leasehold interest. Housing is allocated to first time buyers through non-market mechanisms (Lum, 1997). After owning a HDB unit for two and a half years, the owner is permitted to sell the flat to anyone eligible for public housing at the market price. Sellers can then upgrade their housing by either applying for a larger flat from the HDB or buy private units, or move to similar or smaller apartments and keep their capital gains. Each eligible household can only buy subsidized flats directly from the HDB twice, after which the household can only buy from the resale market or private developers. Since 1971, a mature resale market for these flats has been established, although the HDB continues to regulate eligibility and credit conditions. The table below very briefly outlines the eligibility criteria for purchasing new and resale public sector units.

In 1989, the income ceiling restriction was removed for HDB resale flats and the resale market was opened to permanent residents and private property owners who

had to owner-occupy their HDB flats. The eligibility criteria were further relaxed when single citizens above the age of 35 were allowed to buy HDB 3-room or smaller resale flats outside the central area for owner-occupancy.

Eligibility conditions for purchase of HDB flats. Source: Housing and Development Board (HDB) website at www.hdb.gov.sg

Flat type	Floor area (m ²)	Eligibility conditions	
		Buying a flat direct from HDB	Buying a resale flat on the open market
3-Room	69	Singapore citizen; at least 21 years of age; have a nucleus family; total household income not more than \$2000 per month for 3-room flat/\$8000 per month for 4- & 5-room flats; must not own any private residential property	Singapore citizen or Singapore permanent resident; at least 21 years old; have a nucleus family; no income ceiling (Housing Grant Scheme for family); private property owners have to owner-occupy their flats; single citizens over 35 allowed to buy, post 1991 (Housing Grant Scheme for singles)
4-Room	100		
5-Room	120		

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