UNCOVERING HOUSING MARKET DYNAMICS AND ITS CORRESPONDING COMMONALITIES

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TABLE OF CONTENTS

SUMMARY

Owner-occupied housing is typically the single most important asset in the households' investment portfolio and the largest component of the private households' wealth. As a result, housing value greatly affects households' consumption and savings opportunities (Case *et al*., 2001). This in turn affects the entire economy. Therefore, an insightful understanding of the characteristics of housing price fluctuations and the aggregate housing market dynamics is important to real estate investment portfolio risk managers to differentiate "good" times from "bad" times; for the economists to incorporate illiquidity biases into pricing; and for regulators to know the common dynamic structure between the economy and housing when formulating economy or housing policy.

Housing price fluctuations and its driving forces constitute a core issue in housing economics (Mankiw and Weil, 1991). However, the theory of real estate cyclical dynamics has not been well developed (Pyhrr *et al.*, 1999). The literature on housing price dynamics has extensively examined the cross-sectional variation in housing prices, driven by the heterogeneity of housing under the hedonic pricing approach, but such studies virtually leave out the time-series variation in housing prices. While the stock-flow model and 4-quadrant model describe housing market dynamics, macroeconomic variables, like real income and interest rate, act as exogenous variables to determine housing demand or supply. It, therefore, omits considerations on the interactions between the housing market and economy that are integral to the market dynamic processes. Moreover, the four-quadrant model ignores the important features of the adjustment process (for e.g. protracted or overshooting); neglects the difference between the "cap" rate and the reciprocal of gross income multiplier; assumes the "cap" rate to be exogenous; sets the long-run equilibrium by trial and error and disregards expectations as well as vacancies (Colwell, 2002). With regard to the literature on the association of housing price and aggregate consumption, although a growing body of research has been carried out, there are inconsistencies pertaining to the role of housing price (and wealth) in explaining consumption.

This research fills the current voids and develops three original theoretical frameworks of analysis (TFA) to investigate the characteristics of housing price dynamics and the aggregated housing market dynamics. In particular, an in-depth investigation is carried out from three different perspectives based on the three TFAs. The first perspective aims to investigate the association of housing price with the macro-economy. Considering private consumption expenditure as an important indicator to the overall economy, it focuses on private consumption changes that are brought about by the housing price effect, which in turn is envisaged to comprise the income effect, substitution effect, and expectation effect along with the housing price cycle. The second perspective investigates housing market dynamics and time-series variations in housing prices driven by a few latent common factors. Rooted in general equilibrium theory, an economic interpretation is developed on such dynamics highlighting the real asset feature of housing and its market illiquidity. The time-series variation in housing prices captures the state of the economy and changing housing market conditions on the whole. The third perspective identifies the dynamic characteristics of housing prices within the momentum and disposition behavioral framework. Under the hypotheses that heterogeneous investors are of two types, i.e. the momentum-prone and the disposition-prone, a second-difference model is obtained to depict the periodic fluctuation of housing price behavior. Such a model depends on three composite parameters: serial correlation, the rate of mean reversion and contemporaneous adjustment towards the long-run equilibrium price. The difference model defines rigorously four types of dynamic structures that overshoot equilibrium and/or that diverge permanently from equilibrium and also analyzes conditions of the structures in the disposition-momentum theory. This TFA suggests that the interaction between the two types of investors acts as a key determinant of housing price dynamics for a given time and for a specific market.

Three empirical validations of the three TFAs are implemented in the context of Singapore’s private housing market, respectively. As more real estate funds and other institutional investors allocate capital into Asian real estate, Singapore has emerged as the world's “hottest” real estate market in 2007 and it is among the top favorites of real estate investors (the Economic Times, 2007). In addition, the private housing market operates in a laissez-faire economic system (Sing *et al*., 2004), and is subject to the full rigor of market forces. Singapore private housing prices also experience the great boom-bust volatility since 1990s.

In Chapter 3, the TFA from the first perspective is presented. A frequency domain based model that employs cross-spectra analysis is consistent with this TFA, and helps to validate it, as its model-free characteristics avoid the problems of model misspecification and parameter estimation error. The results show that housing price affects consumption significantly, depending on the time scale and frequency without a consistent sign. The expectation effect, operating through the capital gain effect, is important in explaining the housing price-consumption relationship and contributes more during the expansion period than the recession period.

Chapter 4 provides the TFA from the second perspective and offers an appropriate research design to the TFA. It revolves on the FHLR (Forni, Hallin, Lippi & Reichlin; 2000, 2001, 2003, 2004, 2005) GDFM (generalized dynamic factor model) specification that enables us to estimate the aggregate housing market dynamics and the time-series variation in housing prices driven by a few underlying common factors by utilizing vast information. A robust result shows the existence of two common factors underlying housing market dynamics between 1988 and 2007. The housing market-wide series that are highly related to financial conditions are found to have a high degree of commonality. The explanation power of time-series variation in housing prices on their observed prices is found to be higher during the period when housing prices experience high volatility. This overall approach and empirical results are helpful in enhancing the accurate specification and validity of the economic implications for housing market dynamics.

Chapter 5 presents the TFA from the third perspective and the corresponding empirical work. The analysis suggests a high autocorrelation (66% to 77%) and a low mean-reversion (2.3% to 3.5%) for private housing price behavior in Singapore. During the 1990s, the behavioral price dynamics show convergence and oscillations while from 1982

Q1 to 2007 Q3, the behavioral price dynamics show convergence without oscillations. Although the interaction between the two types of investors acts as a key determinant of housing price dynamics for a given time and for a specific market, the disposition-prone investor predominates the momentum-prone investor in Singapore’s case.

In Chapter 6, the findings are summarized. Implications and future areas of research are discussed.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 Research Motivation

Real estate and for example, housing, has been more and more realized to be a real asset[1] and international investors have increased the real estate share in their multi-asset portfolios (Witkiewicz, 2002). Some researchers claim that institutional investors should increase the real estate weights in their investment portfolios (see Chun *et al*, 2004). Moreover, owner-occupied housing is typically the single most important asset in the households' investment portfolio[2] (Tracy *et al*, 1999) and the largest component of the private households' wealth. As a result, housing value greatly affects households' consumption and savings opportunities (Case *et al*., 2001) that in turn affect the financial sector[3] and the economy[4]. Housing market conditions are often viewed as a yardstick of economic performance. However, significantly different from standard financial assets (equities or bonds), housing real estate shows its unique features like heterogeneity within a fixed location, lumpy transaction costs and the non-instantaneous adjustments in response to housing price fluctuations. These lead to the incomplete and illiquid housing market. Therefore, an insightful understanding of housing price variations and housing market dynamics is imperative for a portfolio risk manager to differentiate "good" times from "bad" times; for an economist to incorporate illiquidity biases into pricing; and for a

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[1] Dusansky and Koc (2006) obtain the empirical upward sloping housing demand based on their augmented Slutsky-Hicks equation, which implies that housing has sufficiently strong potential for capital gain and such an asset role dominates its consumable good role.

[2] See also Flavin and Yamashita (2002).

[3] See Crawford and Rosenblatt (1995).

[4] See Economist (2005).

regulator to know the common dynamic interaction between the economy and housing when formulating policy.

The association of housing prices to the overall economy is complicated and interrelated. The explanation of such an association remains ambiguous from different theoretical perspectives and empirical findings. According to the life-cycle theory on consumption, consumers' expenditures depend on human capital, the value of tangible and financial assets (Deaton, 1992). Housing real estate, as one of the most important non-financial assets in household wealth, affects household consumption through housing wealth. Alternative explanations exist like collateral enhancement and the balance sheet effect, which assumes that households face binding credit restrictions, and that credit instruments allow the withdrawal of housing equity for consumption. Empirical findings on the housing price-consumption issue are also inconsistent like the variation in non-financial wealth that has no effect on aggregated consumption (Elliott, 1980). The marginal propensity to consume from housing wealth is approximately 6% (Skinner, 1993). There is a statistically significant and large effect of housing wealth on household consumption (Case *et al.*, 2001). Nevertheless, the wealth effect is ambiguous and becomes more important over time (Ludwig and Slok, 2002). Lettau and Ludvigson (2004) make an important breakthrough through the vector error correction model (VECM). They propose a permanent transitory variance decomposition framework to separate the trend and cyclical effect that consumption has on asset values. Using U.S. data, they conclude that consumption responds differently to temporary changes in wealth than to permanent ones. Although transitory variation in asset wealth is quantitatively large and highly persistent, the transitory shocks in wealth are found to be unrelated to consumption, contemporaneously and at any future date. Chen (2006) applies the same framework to Sweden data in order to differentiate the wealth component effects on consumption. Permanent changes in housing wealth are found to have long-run effects on consumption, not so for the transitory changes. Both the studies of Lettau and Ludvigson (2004) and Chen (2006) are based on the life-cycle permanent income consumption theory, under a general equilibrium framework from the macro perspective. No theory focuses on the individual's optimum behavior to explain the association of housing price and private consumption.

As for the aggregate models of the housing market, the earlier classical studies are rooted in a basic two-equation stock-flow model of the housing sector with the quick market-clearing assumption. Socioeconomic variables (for e.g. real income and demographic characteristics) act as exogenous variables in determining housing demand, while housing supply depends on new construction, depreciation, housing prices and various interest rates. Such models are refined in DiPasquale and Wheaton (1994) by providing clear evidence on the gradual price adjustment process in the housing market. Later, Colwell (2002) revises the elegant four-quadrant model of DiPasquale and Wheaton by highlighting several negative attributes, for e.g. the exogenous "cap" rate and ignoring expectations and vacancies. Coherence is inferred to emerge from the apparent chaos of the market adjustment process. However, it lacks the systematic economic interpretation and estimation of housing market dynamics concerning its non-instantaneous adjustments.

Cyclical dynamics of real estate prices pervasively affect investment returns and risks (Pyhrr *et al*, 2003) and in particular, is critically important in project development, portfolio management and real estate finance (Wernecke *et al*, 2004). In addition, housing price fluctuations and its driving forces constitute a core issue in housing economics (Mankiw and Weil, 1991). However, the theory of real estate cyclical dynamics has not been well developed (Pyhrr *et al*, 1999). Capozza *et al.* (2004) have conducted novel work on the dynamic characteristics of housing prices that higlight positive autocorrelation[5] and mean reversion. According to the correlation and reversion parameters, four types of dynamics are rigorously defined if prices overshoot equilibrium ("cycles") and/or diverge permanently from equilibrium. Using 1979-1995 data for 62 metro areas and conditional on economic proxies like information costs, supply costs and expectation, they find that the dynamic features (i.e. the four kinds of dynamics) are specific to the given time span and the market being studied. For Capozza's prerequisite definitions, the momentum property of housing markets (the positive correlation between housing prices and transaction volume) has been observed across many different markets[6]. This phenomenon prompts many explanations, for e.g. prospect theory in Genesove and Mayer (2001) and the down payment constraints on buyers, owing to the credit market imprecations in Stein (1995). Glaeser and Gyourko (2006) mathematically deduce the form of the stylized features (autocorrelation and mean reversion) in housing price dynamics based on a spatial equilibrium, and they investigate the reasons for such features. However, their model fails to explain high frequency positive autocorrelation and does not fully explain both features in the most volatile markets. There is no

[5] See Capozza and Seguin (1996).
[6] See Ortalo-Magne and Rady (1998).

systematic theory to explain housing price dynamics and identify its characteristics within a behavioral context.

1.2 Research Objectives

As we know, there exist a vast literature on the real estate cycle or housing cycle during 1990s across many journals. Generally, during that period, most studies are based on two kinds of traditional theories, i.e. the representative agent model and the stock-flow model (the famous four-quadrant model). However, the two models reach similar reduced forms in order to be applicable for empirical study. Although the reduced form has been partly criticized to be inappropriate, it is widely used in practice. Researchers mainly focus on different econometric methods like cointegration, vector auto regression and the vector error corrected model to model the housing price fluctuations during that period.

Following the “boom” of studies on the real estate cycle around 1998, a dearth still remins. Until 2004, new trends that study housing price dynamics have emerged. In my opinion, these studies can be broadly categorized into three directions.

First, more and more scholars pay due attention to the interrelationships between the housing market and macroeconomics to offer theoretical contributions. To make it simple to enable further study, some researchers start within the microeconomics context and migrate to consumption expenditure and ultimately to the whole economy. However, as reviewed in Section 2.2, the literature on the housing price/wealth-consumption is inconsistent from different theoretical aspects using different models with different data sets.

Secondly, some researchers try to develop the theoretical interpretations on housing market dynamics in the equilibrium context. According to Glaeser (2000), the hypothesized links between housing and the macro-economy include the wealth-consumption association (marginal propensity to consume out of housing), the construction sector[7], the banking sector[8] and the allocating function of workers and firms for real estate across geographic space. On the spatial aspect, Glaeser and Gyourko (2006) calibrate a dynamic rational explanation model of housing in a cross-city spatial equilibrium. The results show that the predictability of housing price changes is compatible with the no-arbitrage rational expectations equilibrium. Average volatility and longer-term mean reversion of housing prices is explained through spatial equilibrium, incorporating housing supply. The housing price positive autocorrelation at high frequency, however, is still a puzzle. In addition, Davis and Heathcote (2005) pay due attention to the important role of housing investment in economic growth. They calibrate a multi-sector growth model to replicate the observed facts of the co-movement of real GDP, consumption, housing and non-housing investment. However, their model cannot explain what accounts for the strong lead of housing investment over the business cycle. Meanwhile, the model does not consider demand shocks that affect prices.

[7] Although there is a clear connection between the construction sector and the macro-eocnomy, it is hard to believe that construction will ever be big enough to drive much in the macro-economy (Glaeser, 2000). However, Foldvary (1991) argues that “a real-estate-induced theory of business cycles requires the inclusion of the construction industry, and it is incomplete without also taking into account complementary monetary force”.

[8] Borrowing against real estate values has been a major source of credit expansion and contraction for businesses if not for consumers like in the economies of Hong Kong and Japan (Glaeser, 2000).

Thirdly and since the "anomalies" in housing market are either ignored by traditional economics or dismissed by the assumptions of the agents "rationality" or "efficient market", a related field pertaining to social learning and herd behavior theory, can help to explain the puzzle[9] of housing price performance from a microscopic perspective. As Chamley (2004) reiterates, "individuals learn from the observations of actions, from the outcomes of these actions, and from what others say. They may delay or make an immediate decision, they may compete against others or gain from cooperation; they make decisions about capital or financial investment. A recurrent theme is that society may learn more if individuals are less than perfectly rational in their interpretation of others' behavior". The fast-changing characteristics of the financial market can easily expose the psychological and behavioral factors of agents while these factors are still covered in the connections and movements of various economics variables in other economic areas. Thus, the herd/social learning theory is applied in finance extensively (for e.g. in those studies by Decamps and Lovo, 2006; Chang *et al.,* 2000; Kim *et al,* 2004). However and so far, very limited studies have been done to explain housing price dynamics that are rooted in behavioral finance.

Hence, to fill in the knowledge gaps and to insightfully investigate housing market dynamics and its corresponding commonalities; this dissertation is developed from three different perspectives. In particular, the main objectives of this research involve the following:

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[9] Bruse and Schwab (1985), Case and Shiller (1989, 1990), Hosios and Pesando (1991) and Meese and Wallace (1994) report that house price movements are positively correlated over the short run. More importantly, information on housing market fundamentals and past price increases can be employed to forecast future excess returns.

- To establish a theoretical framework on private consumption changes that are brought about by the housing price effect along with the housing price cycle; and then to conduct an empirical validation that examines the pattern of the housing price-consumption association along with the housing price cycle in Singapore;
- To provide the economic interpretation on the aggregate housing market dynamics within general equilibrium-disequilibrium framework; and then to estimate housing market dynamics, which is driven by a few unobservable common factors and the explanation power of the time-series variation of housing prices on observed housing prices under such housing market dynamics in the aggregate, utilizing Singapore data;
- To develop a theoretical model within a momentum-disposition behavioral context to explain housing price dynamics and rigorously define the different types of housing price dynamics; then to conduct the empirical validation of this theoretical work within the context of Singapore's private housing market to identify the driving forces and characteristics of housing price dynamics.

1.3 Research Questions

Given the foregoing considerations, this dissertation's study seeks to investigate housing market dynamics and its commonalities. Thus, the appropriate research questions include the following as outlined below:

- What is the pattern of the cyclical association of housing price and private consumption?

- How many latent common factors exist to drive housing market dynamics[10]?
- Which housing market-wide factors would obtain a high degree of commonality?
- To what extent should illiquidity be associated with housing market dynamics?
- What are the driving forces and the characteristics of housing price dynamics in a momentum-disposition behavioral context?

1.4 Significance and Contribution

Several original research contributions are duly noted for the present study. From the theoretical perspective, first, a distinguishing theoretical contribution lies in the explanation of the housing price-consumption association, focusing on the individual's optimum behavior. The framework also captures the dual characteristics of housing real estate as both a consumable good and an investment asset. The impact of housing price on private consumption has three effects: the income effect, substitution effect and expectation effect. The expectation effect focuses on the consumers' formation of expectations on housing prices.

Secondly, this study establishes the economic interpretation of housing market dynamics and time-series variation in housing prices from a theoretical perspective. It proposes a systematic approach that is consistent with economy theory to explore housing market dynamics. Housing market dynamics are no longer indicated by a single variable like the conventionally used housing price, transaction volume or supply. Instead, housing market dynamics are measured and estimated taking advantage of more market information as well as the retention of highly correlated leading-lagging variables in a large dataset. The

[10] In this study, we concern about how many latent common factors exist and drive housing market dynamics rather than what the common factors are. More detailed information is provided on page 98.

extent to which each series' dynamics is related to market dynamics is also estimated, and this is key to uncovering some evidence pertaining to intertemporal changes in housing prices and general economic conditions.

Thirdly, it offers a generic and rigorous modeling of behavioral housing price dynamics, inclusive of autocorrelation and mean-reversion, by relaxing the homogenous investors' assumption. Fourthly, this study models the characteristics of housing price dynamics within the disposition-momentum theory through defining four kinds of dynamic structures inclusive of the price bubble. Fifthly, this study relates the disposition-momentum behavioral theory to the stylized facts of housing price dynamics. Sixthly, it validates the autocorrelation and mean-reversion facts over time and the bubble conjecture in the Singapore context. It sheds lights on the observed positive correlations between housing prices and trading volumes as well as the impact from past housing price changes on housing turnover.

From a methodological perspective, this study develops the *ad hoc* functional form of the GDFM (generalized dynamic factor model). It augments the GDFM and estimates housing market dynamics utilizing the potential dynamic common information in Singapore's datasets. Such a methodological perspective takes place within the same unified setting of the GDFM approach, and it enables us to get a more profound understanding of the systematic dynamics as compared to the conventional reduced-form approach. The time-series variation in housing prices is a solution that allows the leading-lagging dynamic structure to be embedded in the observed market information.

From a practical perspective, this study also contributes to the overall work of policy makers and investment managers in enhancing their in-depth understanding of the effectiveness of housing policy, and of the efficiency of real estate portfolio management. For e.g., it sheds light on the recurrent argument that a monetary authority should react to large housing asset price dynamics in order to control the damaging effects on the economy that are associated with price busts or booms.

1.5 Organization of the Dissertation

As discussed above, this dissertation's study develops three theoretical frameworks of analysis (TFA) from three perspectives to investigate housing market dynamics and its corresponding commonalities. Based on each TFA, three empirical validations are carried out respectively. Together the three TFA replace the original theoretical framework for this dissertation's study on housing market dynamics from different perspectives, rooted in different theories. Specifically, the three TFA cover the following three perspectives:

1st, a theoretical framework that extends the two-period model of Dusansky and Koc (2006) and explains the cyclical association of housing prices and private consumption expenditure;

2nd, a general equilibrium theoretical framework that explains housing market dynamics taking into account the illiquidity features of the housing market;

3rd, a disposition-momentum behavioral theoretical framework that explains housing price dynamics.

The first TFA is rooted in microeconomics and focuses on the association of housing prices and private consumption expenditure. Such an association serves as a major channel of interaction between the housing market and the economy in the literature. The novelty of the TFA lies in the association that is explained from a cyclical perspective, based on the Slutsky-Hicks equation but highlighting housing's unique real asset feature.

Since housing is viewed as an important sector in the whole economy by virtue of its cyclical volume dynamics (Leamer, 2007), the second TFA is rooted in general equilibrium theory and extends the first TFA (one channel between housing market and macro-economy) to a much wider one (more channels). This TFA offers a more extensive perspective from which the socio-economic variables serve as endogenous ones in housing market dynamics. The novelty of this TFA lies in the economic interpretation of housing market dynamics that arises from the adjustments between disequilibrium and equilibrium when taking into account the special illiquidity characteristics of the housing market.

The third TFA is rooted in behavioral finance and is an integral part to explain housing price dynamics. This TFA extends the first TFA and the second TFA from their fundamental based economic perspective to a behavioral finance perspective. It is a different perspective from which socio-economic variables act as exogenous ones in housing price dynamics. Its originality lies in the novel perspective from which housing price dynamics is explained within a disposition-momentum behavioral framework.

As a result, this dissertation is organized into six chapters and its structure is shown in Fig 1.1.

Chapter 1 introduces the research motivations, research objectives, specific research questions, significance and contribution of research, and the organization of the dissertation.

Chapter 2 reviews the related literature of theoretical underpinnings and empirical work on housing market dynamics and its commonalities from three perspectives. First, the comprehensive review on housing price-consumption relationships covers the classical economics explanation, housing wealth effect, housing collateralized effect, interest rate-housing wealth effect, household and renter behavior effect and causality between housing price and consumption. The inconsistent explanations and empirical results are revealed. Secondly, the discussion on aggregated housing market dynamics and the dynamic factor model (DFM) approach examine the driving forces, the relations between the housing market and the economy, the development and applications of the DFM. From the foregoing reviews, the knowledge gaps are surfaced accordingly. Thirdly, the review on housing price dynamics and the disposition-momentum effects discusses the existence, methodologies and theoretical underpinnings of housing price cyclical dynamics, real estate speculative bubble and the time path of real estate price movements as well as the existence of various explanations on the disposition and momentum effects in asset markets.

Chapter 3 presents a theoretical investigation of housing market dynamics and its commonalities from the first perspective. It focuses on the association of housing price with the economy as indicated by private consumption from a cyclical perspective. An empirical validation is conducted in the Singapore context using a frequency domain-based model that adopts cross-spectra analysis, as its model-free characteristics avoid the problems of model misspecification and parameter estimation error. As expected, housing price affects consumption significantly, depending on the time scale and frequency without a consistent sign.

Chapter 4 offers the economic interpretation of housing market dynamics and its corresponding commonalities from the second perspective. It focuses on the aggregate housing market dynamics based on general equilibrium theory and the disequilibrium adjustment process. Consistent with such a TFA, the GDFM (generalized dynamic factor model) is adopted to carry out the empirical study in the case of Singapore. The advantages, specifications and estimations of GDFM are introduced. This is followed by the empirical results and analysis, robust checks and summarization.

Chapter 5 provides the TFA from the third perspective to explain housing price dynamics within a disposition-momentum behavioral framework. A second-order difference model of housing price dynamics is constructed. Based on the model, four propositions are derived including the explanation of the stylized facts (autocorrelation and mean-reversion) in housing prices within a disposition-momentum context, the rigorous definitions of four types of housing price dynamics, and the features of amplitude and frequency when housing price fluctuates in oscillations. A further empirical validation is carried out in the context of Singapore's private housing market. The unique explanation and the rigorous definitions provide an in-depth understanding of the housing price dynamics.

Chapter 6 summarizes the findings and conclusion of this research. The implications for theory, practice and policy, as well as research limitations and suggestions for future research are also discussed.

CHAPTER 2 REVIEW OF RELATED LITERATURE

2.1 Introduction

This Chapter provides a fundamental review on the existing theoretical underpinnings and empirical knowledge to understand housing market dynamics. The structure of this review evolves along three strands in line with the research objectives and the subsequent theoretical framework, namely, the housing price-consumption relationship, explanation of housing market dynamics under a generalized dynamic factor approach, and the explanation of housing price dynamics within a disposition-momentum behavioral framework. The three strands of the review are discussed in Section 2.2, Section 2.3 and Section 2.4. The corresponding knowledge gaps are surfaced for each strand. Lastly, this Chapter is summarized in Section 2.5.

2.2 On Housing Price-Consumption Association

The correlation between household wealth and aggregate consumption is a deep-rooted issue in classical economics. It has motivated many empirical studies.

Economics on the Housing-Consumption Linkage

Classical economics sheds light on the housing consumption linkage, which can be traced back to the description by Keynes (1936), who employed a consumption function to express consumer spending. Total consumption is the sum of autonomous consumption and induced consumption, as follows:

$$C = a + MPC * Y \tag{2.1}$$

where MPC is the marginal propensity to consume and Y is disposable income (income after taxes and transfer payments). This Keynesian consumption function is regarded as the absolute income hypothesis, as it entirely bases consumption on current income while ignoring potential future income. Later, criticism of this led to the development of Friedman's (1957) permanent income hypothesis (PIH) and Modigliani's (1988) life cycle hypothesis (LCH). They both serve as a basic starting point to explain the wealth effect on consumer spending. PIH states that a consumer's spending decisions are determined by longer-term income expectations. The key determinant of consumption is an individual's real wealth, not his current real disposable income. Hence, consumers try to smooth out spending based on their estimates of permanent income. The LCH assumes that a consumer spends a constant percentage of the present value of lifetime income. Ando and Moligliani (1963) propose to include wealth in the consumption function (also see Deaton, 1992) and visualize consumption choices as being integrated in an intertemporal optimization program as:

$$C_t = c_Y Y_t + c_A A_t + c_H H_t \tag{2.2}$$

The wealth affecting consumption, here, comprises human wealth (Y_t), net financial wealth (A_t), and tangible wealth (H_t). The weights (MPCs) on them could plausibly vary, given their varying liquidity and the possibility of liquidity constraints on households in general. Therefore, there are differing opinions regarding the effects of consumption on housing wealth.

Housing Wealth Effect

Housing wealth effect is a concept that describes how housing price (wealth) impacts consumers purchasing decisions. Soaring housing prices induce people to feel that their wealth has increased and that their assets are more than they need. Consumers will then increase their consumption in order to return their assets to their equilibrium to income ratio. This channel of consumption rises due to optimistic future estimation or psychological satisfaction, which is consistent with the household's "mental accounts" framework developed in Shefrin and Thaler (1988) and Thaler (1990).

However, the imagined housing wealth effect is controversial concerning difficulties in using housing equity gains. For example, in Engelhardt's (1996) study with U.S. micro data, homeowners' consumption is found to react to capital losses in housing wealth instead of to capital gains in housing wealth. He explains it as a result of obstacles of liquidating housing capital gains or householders' suspicion on the degree of permanency of housing price increases. In Singapore, Phang (2004) found no evidence of private housing price affecting consumption. He attributes the result to the institutional obstacles to extracting housing equity gains. In addition, the intergenerational bequest culture (motive) and regarding a house as the most standing symbol of social status make the housing asset a so-called "an end in itself" (Case, *et al*., 2001).

Interestingly, and taking into account expected inheritance including housing wealth, the parental housing value or net wealth is found to have a positive influence on the consumption of adult children (Hrung, 2002; 2004). Thus, there are two kinds of housing wealth effects: "realized wealth effect" and "unrealized wealth effect" named by Ludwig and Slok (2002). The realized wealth effect occurs when households consume more after cashing in their housing capital gains. The unrealized wealth effect happens when households consume more because they believe they are richer than before.

Housing Collateralized Effect

The "credit channel" is another mechanism linking housing value with consumption. Consumers who own homes have equity with which they can more easily pledge to repay loans, hence overcoming commitment problems in credit markets. This is the "relaxation of borrowing constraints effect" investigated by Lustig and Van Nieuwerburgh (2004) and the "liquidity constraint effect" denoted by Ludwig and Slok (2002). Iacoviello (2004) develops a dynamic general equilibrium model in which housing (collateral) values affect debt capacity and consumption possibilities for a fraction of households. Then an aggregate consumption Euler equation is derived. The results are robust to support housing prices as a driving force in consumption fluctuations. Several studies develop the idea that in the presence of collateralized loans, borrowing constraints distort the intratemporal allocation of resources even between durables and nondurables (e.g., Eun, *et al*., 1995; and Alessie, *et al*., 1997).

This "credit channel" effect evokes Lehnert's (2004) conjecture that if the financial innovation and liberalization over the past decade have made borrowing against housing equity cheaper and easier, consumption should increase as borrowing constraints are relaxed. This, however, awaits further empirical evidence.

Interest Rate-Housing Wealth Effect

There is a major alternative theory based on the Euler equation to the LCH on consumption. This theory seeks to aggregate the optimal intertemporal consumption decision of a representative consumer characterized by rational expectations (Hall, 1978). Consumption is suggested to be a random walk with a discount factor such as the real interest rate being the only relevant driving variable. Interest rate, hence, is regarded as some potential factor on the linkage between the housing price and consumption. According to Dombrecht and Wouters (1997), the transmission channels of interest rate reductions to household consumption and housing investment are classified as follows: (1) interest rate reductions cause portfolio reallocations from financial assets toward real assets like housing; (2) this portfolio reallocation induces upward pressure on bonds, shares, and real estate prices, all tending to increase the market value of households' wealth and hence consumption expenditures [i.e. the "indirect effect" in HM Treasury (2003)]; and (3) interest rate declines imply the reductions in income come from overall wealth and may therefore may negatively impact consumption [i.e. the "direct effect" in HM Treasury (2003)].

Household and Renter Behavior Effect

Further investigation of the housing price-consumption issue will touch on behavioral finance by identifying the household's mortgage refinancing behavior effect on consumption. Although the impact of capital gains on spending may be, as mentioned above, a function of whether or not the gain is realized; in principle, unrealized gains can be borrowed against, through home mortgage re- financing. In Paiella (2007), the consumer is considered to distribute anticipated changes in wealth over time; hence, the MPC out of all wealth, whatever its form, should be the same small number, just over the real interest rate. In practice, however, household behavior is not so correctly timed as to follow the nominal interest rate. This still needs more empirical study.

Renters, as part of potential homebuyers, respond significantly to the housing price increases. It is also a channel through which housing price affects consumption. According to the extensive observations from different regions, some economists argue that to some extent, housing equity can serve as a precautionary buffer against economic adversity, and increases in house price may induce the “forced savings” of renters, thereby dampening their consumption. It is called the “budget constraint effect” in Skinner (1989, 1993) and Ludwig and Slok (2002). The rise in housing prices benefits homeowners who aim to trade down but harms those who have not yet entered the market or want to trade up (Masnick *et al*., 2005). In the aggregate, if gainers and losers balance out, assuming that the net migration and foreign demand for housing are insignificant, then the wealth effect of house price rises on consumer spending is argued to be zero (i.e. housing price changes can redistribute wealth rather than increase it in the aggregate). It is considered as the “Ricardian equivalence result”, (Skinner, 1989). However, there is also alternative possibility, as well reviewed in Chen (2006): facing the soaring housing prices, some renters or people eager to trade up may expedite their home purchase plan. The reason lies with higher rents as compared with mortgage payments or renters’ worry about the more expensive costs of houses in the next period. It is analyzed as the self-fulfilling and self-amplifying prophecies of housing price dynamics in Stein (1995) and Shiller (2004). From the saving aspect, the increases in housing price, however, induce renters to reduce their savings (see Yoshikawa and Ohtake, 1989; and Engelhardt, 1994). Again, the literature fails to provide a consistent prediction for renters' possible reactions.

Causality between Housing Price and Consumption

Some studies provide evidences on the causality transmission mechanism between wealth and consumption. For example, Iacoviello (2004) focuses on the housing collateral effect affecting debt capacity and finds robust results supporting housing prices as a driving force of consumption fluctuations. In Lyhagen (2001), the hypothesis that changes in wealth deliver a direct effect on movements in consumption is supported when attitudes towards future income are controlled. Brodin and Nymoen (1992) using data for Norway also display some clues of the existence of causality.

However, the clear worldwide observations on comovement between housing price (wealth) and consumption are not enough to stop some economists suspecting it a statistical artifact without causality. For example, as Paiella (2007) argues, the MPC out of the wealth estimated by traditional macroeconomic analysis conveys no information about householder behavior, and consequently, about the timing as well as the nature of the "wealth effects" that changes in asset prices might have on consumption. She highlights the consumption response to a wealth shock. She calls the causality a "direct channel," which operates directly through budget constraint. However, she finds that the wealth effects in Italy appears to be small and are unlikely to be direct. According to Aoki *et al*., (2004), housing prices are correlated with housing transaction volume, and transactions seem to be correlated with consumption as people buy goods that are complimentary to housing like furniture, carpets, etc. Another non-causality channel is also proposed by them as housing prices may affect the economy directly instead of via consumption, such as for the case of the United Kingdom where housing prices enter directly into the retail price index via housing depreciation that, in turn depends on the level of housing prices.

It is clear that the sign and magnitude of housing price effect on consumption depend on various channels. There are some common elements among these different channels, while there are others that are competing. As Chen (2006) argues, for a certain economy, it is not feasible to determine an *a priori* relationship between housing price and consumption, nor the strength of this relationship, which must be empirically investigated. Hence, the association between housing price and consumption can be regarded as an empirical result derived from some consistent economic theory for a given economy and within a certain period.

2.3 On Housing Market Dynamics and the Dynamic Factor Model

Since this literature strand serves to explain housing market dynamics under a GDFM approach, a brief review is presented in two branches, i.e. housing market dynamics and DFM.

Housing Market Dynamics: Driving Forces

The driving forces of housing price fluctuations constitute a core issue in housing economics (Mankiw and Weil, 1991), thereby compelling researchers to seek answers from economic fundamentals. A representative work is done by Wheaton (1999). He formulizes the repeated economic shocks and those undergoing a continuing endogenous oscillation including expectations of agents, the development lag, as well as the degree of durability and market elasticities in a stock-flow framework, respectively, to explore the fundamental forces across different real estate types. His simulation results reveal that the dynamic behavior modeled is affected by all these factors, but varies sharply over them. Moreover, real estate market behavior and investment performance are found to be fundamentally different over real estate types. Another line extensively exists to statistically explore the determinants of housing price fluctuations. For example, Hort (1998) estimates Swedish real housing price changes applying a restricted error-correction model. The results reveal that movements in income, user costs and construction costs significantly affect the real prices in the long run. The development of fundamental demand conditions also explains the real prices dynamics (also see Malpezzi, 1999).

Housing and the Macro-economy

Recently, growing recognition on the importance of the interplay[11] between and among housing market and the macro-economy appeals to more and more researchers. Some of them provide qualitative illustrations and try to dig out the roots of the complicated associations between housing and macro-economy through approaches that focus on economic analysis. For example, Kim (2004) provides a comprehensive and intriguing overview of the housing sector as an integral component of the Korean economy. He analyzes the key aspects of the linkages, such as the size, growth, and volatility of housing investment in conjunction with short-run macro-economy fluctuations and long-run resource allocation. He also analyzes the evolution of housing finance and its implications for housing price movement via consumer spending and inflation. Leung (2004) presents another representative study related to housing and the macro-economy. He extensively reviews the existing relevant literature concerning housing market and taxation, housing market cycles and the housing market–urban structural form. Catte *et al*. (2004) analyze the links between the housing price movements and macro-economy in OECD countries. They summarize the structural determinants of house price variability and the properties of housing market's efficiency (resilience) to shocks. Additionally, Case *et al*. (2000) thoroughly investigate the association of the real estate market and the macro-economy performance in several dimensions. The work is summarized by another co-author Glaeser as four hypothesized connections, namely, the construction sector[12],

[11] Kuznets (1977) reports a quite evident and somewhat similar cyclical pattern in the dynamics of housing prices and the general business. Recently, more of the apparent housing and macro-economy "nexus" is shown by the Asan financial crisis and the housing-consumption effect during 1990s (Edelstein and Kim, 2004).

[12] Although Glaeser (2000) states that the force of construction is hard to be believed to be large enough to drive much of the macro-economy.

the wealth-consumption issue (marginal propensity to consume out of housing)[13], the banking sector and the role of real estate prices in allocating workers and firms geographically.

More researchers study the quantitative interplay of housing and the macro-economy. For example, *at macroeconomic perceptive*, Coulson and Kim (2000) utilize a multi-variate vector autoregressive approach to examine the causality and impact of housing and non-housing investment on GDP and its components. Their model also takes into account the appropriate orthogonalization of the shocks that drive the various components of GDP. Housing investment shocks are concluded as being more important in determining GDP compared to the non-housing investment shocks. While Davis and Heathcote (2005) aim to reproduce the co-movement feathers of the U.S. housing investment, non-housing investment and consumption with respect to GDP in a calibrated multi-sector stochastic growth model. *Synthetically theoretical analyses* are also developed, like housing-economic cycles and housing transactions affected by life-cycle credit constraints (Ortalo-Magne and Rady, 2004); the calibrated dynamic rational explanations model of housing in a cross-city spatial equilibrium theory (Glaeser and Gyourko, 2006). *Alternatively, some single channels* are specifically examined, such as, identifying the dynamic relationship between housing values and interest rates in Korean under cointegration test and spectral analysis (Cho and Ma, 2006); exploring the interaction between housing prices and bank lending in Hong Kong applying the error-correction model (Gerlach and Peng, 2005); measuring and interpreting the dynamic response of real housing prices to money supply shocks in a dynamic equilibrium model (Lastrapes,

[13] See previous Section 2.3 for a detailed review on this linkage.

2002); investigating the dynamic relation between stock prices and housing prices from an international perspective (Quan and Titman, 1999); examining the equilibrium relationship between housing prices and household income in Taiwan using vector autoregression (Chen *et al.*, 2007); assessing the influence of income and interest rates on housing prices using cointegration model (McQuinn and O'Reilly, 2007), etc. However, the cointegarated relationship between housing prices and income are not supported in Gallin (2006) under standard tests and bootstrapped approaches of panel-data tests in USA case. Hence, he argues that the error-correction specification for housing price and income found and applied in the literature seems inappropriate.

On the subject of housing and the macro-economy, there have been several but limited studies concerning the Singapore housing market that is relevant to this dissertation study. A comprehensive outline of the recent studies is tabulated in Table 2.1. The tabulation is self-explanatory and it is meant for information purposes.

Table 2.1 Recent Related Literature on the Singapore Housing Market Studies

Reference	**Theoretical Issue ***	Stock-flow model
	Sample Period	1990-2004
	Dependent Variable	Price represented by the private housing price index and the resale price index of HDB flat; the quantity proxy is donated by the index of housing units supply in the pipeline
Huang and Zhang (2006)	**Independent Variable**	Public hosing prices; private housing prices; CPI; mortgage rate, national income; private housing stock; basic materials costs; labor costs; prime lending rate; GDP
	Methodology	Simultaneous equation model; regressive segmentation method
	Results **	Demand and supply macro-variables are found to be significant determinants of private housing prices over the long run
	Theoretical Issue *	Adaptive expectation and myopic pricing, error-corrected stock-flow model
	Sample Period	1980-2002

Ho (2005)	**Dependent Variable**	Housing units under construction; current housing price
	Independent Variable	Housing stock; construction costs; prime lending rate; income tax; mortgage interest rate; price expectation; average income; number of households
	Methodology	Autoregressive error approach
	Results **	Serial error correction is important for the price and new construction models' fit; price is largely affected by the expectation of future price appreciation and the economic variables, i.e. the number of households and housing stock to household ratio; construction is largely affected by housing stock, price and the economic variables, i.e. construction cost and the prime lending rate
Tu (2004)	**Theoretical Issue ***	A dynamic stock-flow model
	Sample Period	1990-2002
	Dependent Variable	Real private housing price index and the private housing commencements
	Independent Variable	Total housing stock; GDP per capital; user cost (mortgage interest rate and myopic expectation of future housing price appreciation, calculated by moving average of six quarters' housing price index); lagged housing price; building material costs; prime lending rate; unemployment; household income
	Methodology	Cointegration analysis
	Results **	Real GDP per capital and total stock significantly affect housing prices in the long run; user cost, lagged housing prices and public resale housing prices explain the short-run real housing price dynamics.
Bardhan *et al*. (2003)	**Theoretical Issue ***	Dynamic model involving the mortgage lending of Ortalo-Magne and Rady (2002)
	Sample Period	1990-2001
	Dependent Variable	The number of new housing units sold by the private sector each quarter
	Independent Variable	GDP; real Singapore stock price index; real home loan prices; interaction term
	Methodology	Multivariate autoregressive moving-averages model
	Results **	A statistically significant positive financial "wealth effect" drives new private sector housing sales; while a negative lending rate effect is found for such transactions; surprisingly, changes in GDP do not statistically significantly affect the private housing market activity
Ong and Sing (2002)	**Theoretical Issue ***	The relations between unsecuritised and securitised real estate markets in the short run and long run simultaneously
	Sample Period	1990-1999
	Dependent Variable	Public housing price; private housing price
	Independent Variable	Public housing price and lagged public housing price; private housing price and lagged private housing price
	Methodology	Engle–Granger (1987) bivariate cointegration test; error-correction model; Granger causality test

	Results **	Deviations from the long-term relationship tend to be corrected over the short run; bi-directional causality is found and it is stronger from private to public housing markets than the other way around
Sing (2001)	**Theoretical Issue ***	A general housing market dynamic structure
	Sample Period	1988-2000
	Dependent Variable	Changes of the occupied stock of condominium; changes in the commencement of the new condominium construction; condominium price index
	Independent Variable	15-year housing loan interest rate; prime lending rate; labor costs index; basic material costs index; GDP; stocks of completed condominium housing; the number of marriages registered; Singapore stock price index; CPI
	Methodology	2SLS
	Results **	Housing demand is negatively related to lagged price change, lagged housing demand and lagged household formation. The commencement decisions of developers is negatively affected by the lagged housing stock change, current and lagged labor costs, commencements and the prime lending rate
Ho and Cuervo, (1999)	**Theoretical Issue ***	Four-quadrant model of DiPasquale and Wheaton (1996)
	Sample Period	1985-1995
	Dependent Variable	Private housing price index
	Independent Variable	GDP; number of private housing starts; prime lending rate; previous private housing prices
	Methodology	Cointegration analysis
	Results **	The contemporaneous convergence of the four variables exhibits minimum systematic error due to the presence of an error-correction mechanism to account for the short-term deviations from the long-run equilibrium relationships.

NB. * the reference mentioned in the theoretical issue column is not provided in the reference list of this dissertation; ** the listed results are relevant to the current research, selected from the reported results in the papers.

Dynamic Factor Model (DFM): Its Development

The dynamic factor model (DFM) originates from the informal NBER-method proposed by Burns and Mitchell (1946) and it overcomes the shortcomings, like taking equally contemporaneous averages of the series in the aggregate. Instead, the factor model provides a formal representation of index models. It makes identification feasible by dramatically reducing the ranking owing to its assumption that a few factors drive the dataset. As opposed to the static factor model, the "dynamic" factor model means that the common factors hit the series at different times. Recently, the theory of DFM has been seriously developed via the generalized dynamic factor model (GDFM) by Forni, Hallin, Lippi and Reichlin (FHLR) (2000; 2004; 2005), Forni and Lippi (2001). The "generalized" refers to the permission of the idiosyncratic noises to be weakly serial and cross-sectional correlated. Hence, the GDFM combines the approximate static factor model of Chamberlain and Rothschild (1983) and the DFM of Sargent and Sims (1977), Geweke (1977). Later on, Pena and Poncela (2006) propose a non-stationary DFM that allows a set of non-stationary common shocks to explain the common dynamic structure in the time-series vector.

Several ways exist to estimate DFM. One is the maximum-likelihood approach in frequency or time domain (see Quah and Sargent, 1993). Another is various PC methods, such as the conventional and lagged augmented approach in Stock and Watson (1998), the asymptotic features for the conventional PC estimation by Bai (2003), the frequency-domain PC method by Brillinger (1981) and FHLR (2000); or a revised ICA for DFM by Huang *et al*. (2006). An introductory survey to factor models including structural properties is presented by Deistler and Zinner (2007). A comprehensive overview of recent developments in the common features is provided in Urga (2007).

Dynamic Factor Model (DFM): Its Application

The DFM has been widely applied in the economics and business fields as a powerful approach, such as modeling economic activity (for e.g., Bandholz and Funke, 2003; Gerlach and Yiu, 2005), forecasting GDP growth (for e.g., Garcia-Ferrer and Poncela, 2002) or identifying shocks and propagation mechanisms (for e.g., within a VAR framework by Bernanke *et al.*, 2005). In addition, Diebold *et al.* (2005) use the DFM to identify the property of the dynamic interaction between the macro-economy and the yield curve. The latent factors, jointly with observable macroeconomic variables are used to summarize the yield curve. Another major area of applications is finance. More detailed review on the DFMs including its development and application is presented by guest editorial (2004).

2.4 On Housing Price Dynamics and Disposition-Momentum Effect

Real Estate Cyclical Dynamics

Several studies emphasize the existence of the real estate cycles. A recurrent cycle of office construction and vacancy is reiterated by Wheaton (1987) and that of office rents for four European cities by Baum (1999). Some fifty- to sixty-year cycle on real estate returns are suggested in Kaiser (1997). Renaud (1997) proposes the first global cycle, i.e. “the 1985 to 1994 global real estate cycle”, and offers a comprehensive overview that analyzes the factors that trigger such a cycle as well as the impact from the cyclical dynamics. Englund and Ioannides (1993, 1997) name a similar concept as the “international house price cycle”. They provide weak evidence for its existence by comparing the dynamics of housing prices in 15 OECD countries. As for the real estate value or price cycle, different types of real estate exhibit different cyclical patterns over time and across different markets (see Wheaton, 1999; Case and Mayer, 1995). Empirical studies have tried to pin the determinants of real estate price cycles on economic fundamentals. They hone onto the dynamic interrelationships between macro-economic variables and real estate prices. For e.g., Poterba (1991) tests construction costs, the real after-tax user cost of homeownership and demographic factors to explain housing price movements. Muellbauer and Murphy (1997) analyze the UK housing price cyclical behavior by focusing on financial liberalization, the wealth effect and other economic/demographic factors. Quigley (1999) extends the factors to consider the effects of economic conditions and lagged housing prices on price variation. The results show that economic fundamentals merely explain less than 29% of the variation. However, lagged housing prices explain most of housing price variation. Adopting the same approach to explain the housing price dynamics of 46 prefectures in Japan, Seko (2003) obtains contrary findings to those by Quigley (1999). Another line of relevant studies concerns the estimation of housing supply elasticity and price adjustments[14] (see DiPasquale and Wheaton, 1994; Blackley, 1999; Goodman, 2005; Wigren and Wilhelmsson, 2007). These studies also include an opposite perspective to analyze the effects of supply constraints on housing prices (see Aura and Davidoff, 2008). On estimation approaches, the prevailing ones include ordinary least-square, structural vector autoregression (for e.g., Elbourne, 2008) and the error-correction model (for e.g., Hort, 1998; Malpezzi, 1999). Several studies have adopted the artificial neural network

[14] Wigren and Wilhelmsson (2007) provide a detailed review on this issue for recently published articles, while DiPasquale (1999) offers a more complete review.

approach (see Selim, 2008). Granger causality tests and impulse response functions investigate the interaction between housing prices and general economic conditions (see Green, 1997). All these studies have been inspired by the strategic idea that economic fundamentals act as the underlying driving forces of real estate price cycles. Nevertheless, these studies present inconsistent results with respect to specific economic determinants, based on different methodologies and across different areas while the theoretical models for real estate cyclical dynamics have been patchy[15].

In addition, such theoretical models are also relatively scarce. Traditionally, there are two kinds of theories, namely, the representative agent model and the stock-flow model (the popular four-quadrant model). Both accord due attention to economic fundamental determinants. Briefly, the representative agent model considers the new dwelling market and homeowners act as both consumers and investors. The market equilibrium condition is that homeowners obtain the same return from investing in houses in relation to other assets. As for the stock-flow model, two sub-markets are taken into account. The interaction of demand and supply determines housing prices. Therefore, a similar reduced form is derived from the two different theoretical models but the theoretical development on housing cycles is still limited. Some recent research efforts relate to the causes or explanations of housing cyclical fluctuations. The "honeycomb cycle" theory of Janssen *et al*. (1994) reiterates the relevance of market conditions that trigger housing market

[15] Meen (2002) argues and tests that the large difference, as suggested by the literature of the housing prices' time-series behavior in the UK and the US, accounts for the differences in methodological approaches. A common methodology is adopted and the results indicate that a same theory with a same set of variables to model housing prices can explain the behavior in both countries.

cyclical dynamics, and in particular that relevance concerning the interaction between housing price dynamics and transaction volume dynamics. More important, the empirical tests suggest that transaction volume dynamics are more closely related to the changes in market conditions, compared to housing prices dynamics. In Chinloy (1996), the apartment rental rate is a function of the vacancy and the space absorption expectation. Rent expectations and construction lags are empirically found to be significant determinants of housing cycles. Dokko *et al*. (1999) contribute by modeling the interaction of real estate rent cycles with value cycles. Their model links economic fundamentals to real estate value and income cycles via the general relationship between real estate value and the capitalization of expected future rents. Capozza *et al*. (2004) investigate housing price dynamics by focusing on its stylized facts, i.e. serial correlation and man reversion. Utilizing data of 62 metro markets, they conclude that local economic variables, construction costs, the size and the growth of metro area can explain housing price fluctuations.

Real Estate Speculative Bubble

Beyond economic fundamentals, the recent and well-publicized spikes in housing prices and rents are of public concern over the affordability of housing (Quigley and Raphael, 2004). It led to the speculative bubble issue in real estate market. However, the widely used “bubble” [16] has been rarely defined (Case and Shiller, 2003), and “only a handful of studies explicitly test for the existence of speculative bubbles in the housing market”

[16] According to Case and Shiller (2003), the term “housing bubble” is quietly new and the peak in its usage occurred in Oct. 2002.

(Cho, 1996). Clayton (1994) examines the explanation power of a forward-looking rational-expectation housing price model for short-term fluctuations in real housing prices. The joint null hypothesis of rational expectations and the asset-based housing price model is rejected by the tests of cross-equation restrictions, using quarterly housing prices of Vancouver, British Columbia. Abraham and Hendershott (1996) model market fundamentals together with two bubble variables: a bubble builder caused by the expectation of price appreciation over time, and a bubble buster that indicates the periods with actual price being higher than equilibrium. As expected, fundamentals together with bubble variables explain more of the variation (three-fifths) in price movements than the individual ones (two-fifths), utilizing the data of 30 U.S. cities. As for the UK-wide housing market, Levin and Wright (1997) model speculation in the housing market and they conclude that the process of speculation acts as a possible determinant of housing prices. Black *et al*. (2006) model fundamentals, utilizing a time-varying present value approach, to examine actual hosing prices relative to fundamental housing values. In their work, the existence of an explosive rational bubble[17] due to non-fundamental factors is precluded but intrinsic rational bubbles[18] are found to be important in determining actual housing prices. Kim and Suh (1993) incorporate a pure demand model for future capital gain as one argument to specify an asset demand for housing. Then the equilibrium price equation is derived via the forward-expectation approach together with the asset supply function. Utilizing annual data, they report the weak evidence of a growing rationale bubble inherent to Korean housing prices. With quarterly data, the

[17] The explosive rational bubble means that prices deviate and keep such deviation from fundamentals owing to factors extraneous to asset value.
[18] Intrinsic rational bubbles derive all of their variability from exogenous fundamentals instead of from extraneous factors (Froot and Obstfeld, 1991) but periodically revert to their fundamental value.

existence of a bubble could not be established in housing prices. Surveying the related literature, the development of the theoretical explanation on speculative bubbles is still limited. However, some recent empirical studies continue to be conducted (for e.g. those by Hui and Shen, 2006; Fernandez-Kranz and Hon, 2006; Goodman and Thibodeau, 2008; Fraser *et al*. 2008).

Time Path of Real Estate Price Movements

Owing to real estate market inefficiency (Gatzlaff and Tirtiroglu, 1995), a strand of the literature accords due attention to the behavior of actual housing price fluctuations in relation to the market fundamentals. Hott and Monnin (2008) propose two models that estimate housing fundamental values: the rent model based on the no-arbitrage condition between renting and buying, and the demand-supply model that interprets the period costs as a result of market equilibrium between housing demand and supply. Such estimation of fundamental values takes into account two basic elements of housing price assessments, namely, the imputed rent and the effect of income on price as well as the expected future fundamentals. They apply both models to the US, UK, Japan, Switzerland and the Netherlands markets, and found that in the long run, actual prices deviate substantially from their estimated fundamental values but tend to converge to fundamental prices progressively. Stevenson (2008) analyzes the Irish housing price behavior by adopting a number of alternative approaches to estimate fundamental values. He focuses on the extreme condition of the Irish market during the 1990s and he finds that a substantial premium over fundamental values is developed in the late 1990s while prices largely accord with fundamentals recently. Housing price movements are largely justified by economic and demographic fundamentals. Another strand focuses on the predictability and the time path of housing price movements. Considering the boom-bust volatility of housing market, Miles (2008) argues that nonlinear models perform better than the linear ones in forecasting housing price dynamics. The generalized autoregressive (GAR) model is evaluated to be better than the autoregressive-moving average (ARMA) and the generalized autoregressive conditional heteroscedastic (GARCH) models, especially for those markets that traditionally experience significant housing price volatility. Guirguis, *et al*. (2005) apply time varying coefficients to model and forecast US housing prices, and they favor the rolling generalized autoregressive conditional heteroskedastic (GARCH) model and the Kalman Filter with an autoregressive presentation for the parameters' time variation. Birch and Sunderman (2003) report the development and application of a two-way exponential smoothing system for effectively estimating housing price paths, and which indicates true market movements. While Gu (2002) emphasizes the time patterns of housing price movement and the possibility of obtaining excess return, based on the predictability of the ensuing patterns. He finds that more volatile housing price indices tend to be associated with lower rates of retune.

Disposition Effect of Investors' Behavior in the Asset Market

The tendency to sell winners quickly and to hold on to losers, as a prominent portfolio puzzle in the rational expectations paradigm, denotes the disposition effect by Shefrin and Statman (1985). This tendency is found in a variety of markets with different considerations, such as the Finnish stock market (Grinblatt and Keloharju, 2001), the Taiwanese stock market (Barber *et al.*, 2006), the Australian stock market (Brown *et al.*, 2006) and in the exercise of company stock options (Heath *et al.*, 1999). The disposition effect is also found for different periods, such as in the December month when tax-motivated selling prevails. Odean (1998) finds that individual investors demonstrate a significant disposition behavior, which does not seem to take into account the need for rebalancing portfolios nor of trading costs. In contrast, Ferris *et al*. (1988) present overwhelming evidence that the disposition behavior exists throughout the year inclusive of the year-end. The evidence from actual trading records of professional traders also exhibits their myopic loss aversion (Locke and Mann, 2000) although the wealthier and individual investors in professional occupations exhibit less of the disposition effect (Dhar and Zhu, 2002). However, there is partial consensus on the explanation for the disposition effect even though its existence seems undisputed. Favorable behavioral explanations include prospect theory (Kahneman and Tversky 1979), regret aversion (Loomes and Sugden, 1982), mental accounting (Thaler, 1985) and the cognitive dissonance theory (Shefrin and Statman, 1985). As to formal testing, several papers have recently formalized the explanations of prospect theory and loss aversion on the disposition effect. Kyle *et al.* (2006) analyze the liquidation decisions of economic agents and find the evidence that the prospect theory induces agents' disposition behavior. However, Ranguelova (2001) tests the discount brokerage clients' behavior and he finds that the larger the market capitalization of the firm, then the more likely that people realize their gain and hold on to their loss. Such findings challenge the explanation from a prospect-theory type of individual preferences. Instead, they suggest that individual beliefs rather than preferences are generating the disposition effect. In addition, Hens and Vlcek (2005) query the prediction of the disposition effect, based on prospect theory and loss aversion. Barberis and Xiong (2006) obtain a similar conclusion on the regret explanation although the results of Muermann and Volkman (2007) show that an investor seeking pride and avoiding regret, exhibits the disposition trading behavior. A behavioral alternative focuses on rational explanation, such as the portfolio rebalancing consideration (Lakonishok and Smidt, 1986) as well as the transactions cost consideration (Glosten and Harris, 1988).

Momentum Effect of Investors' Behavior in the Asset Market

Jegadeesh and Titman (1993) popularize strategies of buying assets that perform well and of selling assets that perform poorly in the past. However, the consistent profitability of such momentum strategies has puzzling anomalies in modern finance theory by violating the central theme of the efficient market hypothesis. Thus, the momentum effect is universally noted and appears robust to methodological tweaking. Momentum strategies are found to be effective in twelve European countries (Rouwenhorst, 1998), in those Asian markets with the exception of Japan and Korea (Chui *et al*., 2000), given that momentum profits persist throughout the 1990s (Jegadeesh and Titman, 2001). Various explanations allude to the momentum phenomenon. The momentum strategy denotes that psychological phenomena, based on irrational behavior, such as the representative heuristic and conservatism bias by Barberis *et al*. (1998) and the self-attribution bias by

Daniel *et al.* (1998). “Irrational decisions may lead to systematic under- or over- reaction of prices relative to their fundamental value, whatever that may be” (Swinkels, 2004, page 122). Hong and Stein (2000) argue that communication frictions cause under-reaction in the short run and over-reaction at long horizons in keeping with momentum behavior. Another explanation is risk-based, proposed by Jegadeesh and Titman (1993), and yet they fail to provide evidence; neither do Fama and French (1996) with their three-factor unconditional asset pricing model. Ang *et al.* (2001) provide evidence of the momentum profits as compensation for exposure to downside risk.

Other explanations include the cross-sectional variation in the unconditional expected returns, instead of the predictable time-series variation in returns (Conrad and Kaul, 1998) and the industry effects (Moskowitz and Grinblatt, 1999). However, the inconsistent results challenge both explanations (see Jegadeesh and Titman, 2001; Grundy and Martin, 2001). Recently, Antoniou *et al*. (2007) attribute the business cycle variables and behavioral biases in a two-stage model specification that can explain the momentum effect. The reason for the failure of conditional asset pricing models is due to asset mis-pricing that systematically varies with global business conditions. Yet, behavioral variables do not appear to matter much. As a result, the relevant research in this dissertation study does not aim to discuss the explanations on the disposition and momentum behaviors but aims to draw on the extensive existence of the disposition and momentum phenomena, to construct a housing price dynamics model for investigating the characteristics of the housing price time path and for identifying its cyclical movement or speculative bubble movement.

2.5 Summary

This Chapter reviews the related literature along three strands that correspond to the research objectives and the theoretical framework of analyses. The review covers the theoretical underpinnings and empirical studies on each strand.

In terms of the first strand on the housing price-consumption association, a comprehensive review is made including inconsistent empirical results and various explanations via different effects, such as classical economics theory on the housing-consumption linkage, the housing wealth effect, housing collateralized effect, interest rate-housing wealth effect, even household and renter behavioral effect as well as the causality between housing price and consumption. Based on this review, it is summarized that the association between housing price and consumption can be regarded as an empirical result derived from some consistent economic theory for a given economy and within a certain period. This review clearly indicates that existing studies on the housing price-consumption association neglect the intrinsic feature of cyclical dynamics in the housing price and consumption series and the resulting relationships.

The second strand reviews housing market dynamics from a systematic perspective, consisting of the discussion on its driving forces (determinants), the advanced qualitative and quantitative studies of the relationships between housing and the macro-economy as well as a list of the related recent work on the Singapore housing market. Such a review makes it clear that housing market dynamics lacks systematic economic interpretation and estimation. To serve as an appropriate methodology that can be potentially adopted to systematically investigate housing market dynamics, the dynamic factor model is briefly reviewed covering its development and application. In fact the DFM approach has never been applied to a housing market study.

The third strand, i.e. the housing price dynamics and disposition-momentum effect, begins with the real estate cyclical dynamics concerning its existence, various estimation approaches and the relative scare theoretical models; the speculative behavior in real estate market; the time path features of housing price movements; the disposition and momentum effects in asset markets that include their existence and various explanations. The review of this strand uncovers the current knowledge gap on the explanation of housing price dynamics within the disposition-momentum theoretical context.

CHAPTER 3 THE CYCLICAL ASSOCIATION OF HOUSING PRICE AND CONSUMPTION

3.1 Introduction

The large changes in asset prices in the past two decades seem to affect an economy substantially. Economic researchers and monetary policymakers pay increasing attention to the association of housing prices and private consumption. For example, Greenspan (2001) reiterates that “And thus far this year, consumer spending has indeed risen further, presumably assisted in part by a continued rapid growth in the market value of homes.”

However, the explanation for this association remains ambiguous from different theoretical perspectives and empirical findings. According to the life-cycle theory on consumption, consumers’ expenditures depend on human capital, the value of tangible and financial assets (Deaton, 1992). Housing real estate, as one of the most important non-financial assets in household wealth, affects household consumption through housing wealth. However, alternative explanations exist, like collateral enhancement and the balance sheet effect, which assumes that households face binding credit restrictions, and that credit instruments allow the withdrawal of housing equity for consumption. The empirical findings on the housing price-consumption issue are also inconsistent, such as the variation in non-financial wealth that has no effect on aggregated consumption (Elliott, 1980). The marginal propensity to consume from housing wealth is approximately 6% (Skinner, 1993). There is a statistically significant and quite large effect of housing wealth on household consumption (Case, Quigley and Shiller, 2001).

Nevertheless, the wealth effect is ambiguous and becomes more important over time (Ludwig and Slok, 2002).

As a consequence, the private housing market in Singapore is investigated to further explain the housing price-consumption issue, owing to its significant impact on the economy, as well as its large and frequent boom-bust cycles. This market accounts for 52% of the total gross housing wealth while the ratio of the gross private housing wealth to GDP is about 1.48 in Singapore (Phang, 2001). As shown in Fig 5.1, the boom period between 1980 and 1984 occurred as a result of rapid real GDP growth and the Central Provident Fund (CPF) regulation, which has allowed CPF savings (a form of social security) to be used to pay private housing mortgages. Another boom period between 1987 and 1996 was deflated by the government's real estate anti-speculation policy in 1996 and exacerbated by the Asian Financial Crisis in 1997. Although the issue of the housing price-consumption linkages has been extensively studied in Singapore (e.g., Abeysinghe and Choy, 2004; Edelstein and Lum, 2004; and Phang, 2004), their inconsistent results are not comparable owing to the different sample periods and econometric models.

Lettau and Ludvigson (2004) make an important breakthrough through the vector error correction model (VECM). They propose a permanent transitory variance decomposition framework to separate the trend and cyclical effect that consumption has on asset values. Using U.S. data, they conclude that consumption responds differently to temporary changes in wealth than to permanent ones. Although transitory variation in asset wealth is quantitatively large and highly persistent, the transitory shocks in wealth are found to be unrelated to consumption, contemporaneously and at any future date. The wealth in their study is the sum of the human capital and non-human (asset) wealth, which are tradable under a representative agent economy. Chen (2006) applies the same framework to Sweden data in order to differentiate the wealth component effects on consumption. The permanent changes in housing wealth are found to have long-run effects on consumption, not so for the transitory changes.

Nonetheless, both the Lettau and Ludvigson (2004) and Chen (2006) studies are based on the life-cycle permanent income consumption theory, under a general equilibrium framework from the macro perspective. The distinguishing feature of the research in this Chapter roots in a unique theoretical framework developed in Chapter 3, focusing on the individual's optimum behavior, to explain the association between housing price and private consumption. This framework also captures the dual characteristics of housing as both a consumable good and an investment asset. The impact of housing price on private consumption has three effects: the income effect, the substitution effect, and the expectation effect. The expectation effect focuses on the consumers' formation of expectations on housing prices.

In order to take into account the asymmetry in housing prices (Guirguis and Vogel, 2006), the theoretical framework proposed here investigates the housing price effect on consumption from a cyclical perspective. The frequency domain method of the cross-spectral analysis is deployed to identify the existence and strength of the association between housing price and private consumption in Singapore. This study complements the inconsistent empirical results of the housing price-wealth-consumption literature as reviewed in Section 2.2.

The rest of this Chapter is organized as follows: Section 3.2 presents the theoretical work. Section 3.3 introduces the econometric models. Section 3.4 discusses the data and its treatment. Section 3.5 reports and analyzes the empirical results. The findings and implications are then briefly summarized in Section 3.6.

3.2 Theoretical Work

Following the two-period model presented by Dusansky and Wilson (1993) and Dusansky and Koc (2006), the first TFA of this dissertation is developed to explain the association between consumption and housing prices under intertemporal uncertainty. In Period 1, a consumer works to earn income and chooses an optimal amount of consumable goods and owner-occupied housing services. In Period 2, the consumer retires and consumes goods and rental housing. Another assumption is that the consumer sells the owner-occupied housing at the beginning of Period 2 and devotes the sales proceeds to consumable goods and rental services. The formation of expectation on uncertain future prices is crucial (i.e. the links between the current housing prices and expectations of future prices are of importance to the perceptions of potential capital gains and to the implications for the effect of changes in the current housing prices on consumption).

The two-period assumption is feasible and supported by the empirical results in Lehnert (2004) (i.e. that the consumption of the age quintile on the verge of retirement is responsive to housing wealth). Meanwhile, householders aged 52–62 years with the highest sensitivity to housing wealth gains are precisely those preparing to retire and would most likely “downsize” their house.

Specifically, this two-period model is expressed as:

$$U = U(x_1, h_1^o, x_2, h_2^r) \tag{3.1}$$

$$\sum_{i-1}^{n} p_{i1} x_{i1} + p_{o1} h_i^o = Y \tag{3.2}$$

$$\sum_{i-1}^{n} p_{i2} x_{i2} + p_{r2} h_2^r = S + p_{o2} h_1^o \tag{3.3}$$

In Equation (3.1), x_1, x_2 are the vectors of regular consumption goods in the respective periods; h_1^o , h_2^r depict units of owner-occupied and rental housing services in the respective periods. Equations (3.2) and (3.3) describe the budget constraint in the respective periods. p_{i1} , p_{o1} represent the prices of the consumable goods and owner-occupied housing, respectively. Y represents certain earned income or wealth in Period 1. The owner-occupied housing acts both as a consumable good and as an investment asset for the intertemporal transfer of wealth by carrying housing stock into the subsequent retirement period. p_{r2} is the price of a standardized unit of rental services in Period 2; S denotes fixed exogenous income. In Period 2, hence, the budget is constrained by S augmented by the proceeds from the sale of the housing stock.

$$\phi(\overline{x}_1, \overline{h}_1^o, p_2) \tag{3.4}$$

$$V_1(x_1, h_1^o, p_1) = \int_{p2} U[\phi(x_1, h_1^o, \cdot)]dF(\cdot \mid p_1) \tag{3.5}$$

With regard to any particular choice in Period 1, $(\bar{x}_1, \bar{h}_1^o)$, lots of different consumption combinations in the two periods can be envisioned depending on the price system that prevails in Period 2. Among all these possible consumption patterns, one would be interested in only those that are feasible and optimal, denoted by the formula in Equation (3.4) that not only satisfy the Period 2 budget constraints, but also are consistent with utility maximization.

In order to choose the consumption programs in Period 1, the consumer must develop expectations on the equilibrium price system, which might prevail in Period 2. Dusansky and Koc (2006) assume that consumer expectations on future values are based on present ones. Accordingly, the consumer forecasts for Period 2 prices can be depicted by the conditional subjective probability distribution $F(p_2 \mid p_1)$. Hence, the von Neumann–Morgenstern (1947) expected utility function $V_1(\cdot)$ of the action (x_1, h_1^o) can be expressed in Equation (3.5). Following the economic assumption, the consumer here pursues the maximized expected utility. So, the optimization problem turns into maximizing Equation (3.5) subject to Equation (3.2). Usually, the first-order conditions can be solved for the demand functions for consumption goods and owner-occupied housing real estate, respectively. The latter is shown in Equation (3.6) by employing the Slutsky equation:

$$\frac{\partial h^o}{\partial p_o} = -h^o \frac{\partial h^o}{\partial Y} + \lambda \frac{D_{n+1,n+1}}{D} - [\sum_{j=1}^{n} V_{x_j p_o}(\cdot) \frac{D_{j,n+1}}{D} + V_{h^o p_o}(\cdot) \frac{D_{n+1,n+1}}{D}] \tag{3.6}$$

, where D is the determinant of the Jacobian of the first-order conditions. The expression in Equation (3.6) consists of the weighted income effect plus the substitution effect, together with additional terms. The additional terms describe the effect of a changing owner-occupied housing price on the expected utility function, operating through the marginal utilities of all consumable goods and housing services. As a result, the sign of the right hand side of Equation (3.6) is ambiguous and the Slutsky-Hicks properties do not hold as in conventional microeconomics. Moreover, Dusansky and Koc found that housing demand is upward sloping. This implies that housing has sufficiently strong potential for capital gain, which dominates its role as a consumable good.

It is therefore necessary to take into account the expectation effect, which is the impact of housing price changes on consumer buying behavior. Moreover, Guirguis and Vogel (2006) have found that there is asymmetry in real house prices. They state that: "residential price appears to exhibit some price rigidity, reacting more readily to positively lagged changes than to the negative lagged changes in prices. Homeowners may be reacting to negative market changes by temporarily holding off from listing or releasing for selling the existing housing stock. Alternatively, buyers and sellers may simply be adjusting to market conditions, with both sides trying to account for past and future predicted price movements." Their analysis highlights that it is important to incorporate or consider the asymmetry in some relevant study to avoid model misspecification.

In addition, common sense prevails that people tend to easily expect more to gain but be always reluctant to lose. This is described by Duffy et al. (2007) as "a loss-averse investor whose aim is to invest in a static, single-period portfolio that maximizes his expected return at a trading time scale while safeguarding, with high probability, the return from falling below an acceptable level. In this setting, an investor is defined by the trading time scale, the threshold that determines the unacceptable loss and a specified bound on the probability that such a loss occurs." Empirically, loss aversion is an important phenomenon in the metropolitan housing markets in the United States where the nominal loss aversion significantly influences household mobility (Engelhardt, 2003). Theoretically, Rabin (2000, page 1288) argues that "…loss aversion is a departure from expectedutility theory that provides a direct explanation for modest scale risk aversion."

Here, the aim is not to investigate the different risk attitudes or the different loss probabilities along a trading time scale; instead, the goal is to try to differentiate the expectation effects in two different periods: the expansion and recession periods. No matter that cycles in wealth are driven by housing prices and could have contributed to the cyclical nature of overall demand in the past 30 years or explained via the credit market as Aoki (2004) proposes, it is necessary to investigate the relationship between housing price and consumption from a cyclical perspective taking into account the asymmetry in housing price, as well as householders' loss aversion.

The impact of housing price changes on consumption should include three parts: income effect, substitution effect, and the expectation effect. The expectation effect during a recession is smaller than that during expansion, as it is operating through the capital gain effect. Consequently, during the recession period, and if the expectation effect is smaller than the sum of the income effect and the substitution effect, then the housing price impacts consumption negatively. During an expansion period, the expectation effect is larger. If it is large enough to cover the sum of the income effect and the substitution effect, then the housing price impacts consumption positively. Hence, the relationship between housing price and consumption depends on whether there is a recession or expansion in the housing price cycle.

3.3 Spectral Analysis Model

This Chapter seeks to investigate how (i.e. the pattern through which) consumption is affected by changes in current housing prices from a cyclical perspective. In an attempt to estimate such a relationship, the univariate spectral and cross-spectrum density models are deployed.

Spectral analysis, an unconventional ramification in time series econometrics, is purely a mathematical model of a process that generates the underlying series. This inherent model-free characteristic avoids the problem of model misspecification and parameter estimation errors. Moreover, standard regression models will assume the same model for each cycle-duration. The cross-spectral density model provides a solution to these problems. Hence, the univariate spectral and cross-spectra density models are adopted to estimate relationships between housing prices and consumption along with their cyclical mannerisms.

Spectral analysis is essentially a modification of the Fourier analysis to enable a fit for stochastic rather than for deterministic functions of time. Given a function $h(m)$ of an integer variable m, the integer Fourier transform of $h(m)$ is defined as:

$$f(\omega)=\frac{1}{2\pi}\sum_{t=-\infty}^{\infty}h(m)e^{i\omega m}, -\pi\leq\omega\leq\pi\ , \tag{3.7}$$

Here, $f(\omega)$ is only defined in the interval $[-\pi,\pi]$, and to make $f(\omega)$ exist, a sufficient condition is $\sum_{t=-\infty}^{\infty}|h(m)|<\infty$, then, an inversion formula can be obtained as:

$$h(m)=\int_{-\pi}^{\pi}f(\omega)e^{i\omega m}d\omega, m=0,\pm1,\pm2,... \tag{3.8}$$

Usually, the function $h(m)$ in Equation (3.8) is referred to as the inverse Fourier transform of $f(\omega)$ commonly called a Fourier transform pair. In time series analysis, the Fourier transform of the absolutely assumable autocovariance function is named the spectral density function, or spectrum. The spectrum is a continuous function $[-\pi,\pi]$ for a purely indeterministic discrete stationary process. Hence, the spectrum of an indeterministic process with absolutely assumable autocovariance sequence

ce $\lambda(k)$ can be expressed as:

$$f(\omega)=\frac{1}{2\pi}\sum_{k=-\infty}^{\infty}\lambda(k)\cos\omega k=\frac{1}{2\pi}[\lambda(0)+2\sum_{k=1}^{\infty}\lambda(k)\cos\omega k] \tag{3.9}$$

The spectrum and the autocovariance function are equivalent ways to explain a stationary stochastic process. They are complementary to each other in the application. The spectrum interprets the relative power of each frequency component (i.e. its contribution to the total variance of the whole process). For a purely indeterministic discrete stationary process, the total area under the spectrum curve is equivalent to the total variance, and a spike in a particular frequency range indicates the presence of a dominant cyclical component.

In short, the univariate spectral approach splits the time series into a set of mutually uncorrelated components, each one corresponding to a cycle in a different frequency band, from which a periodogram can be portrayed. It describes the amount of variance in the series accounted for by each frequency band cycle. The frequencies are measured in terms of cycles per time period and the important bands of frequencies can be seen via examining a spectrum.

Cross-spectral analysis, essentially, performs lots of regressions between the same frequency cycles in a pair of time series. It can also provide direct estimates of the lead-lag patterns between series' components, which may be fractions of observation period units and differ for different frequency cycles. In some sense, co-spectral analysis can be regarded as the equivalent to the correlation analysis in frequency domain. Cross-spectral representation of the relationship between two time series is summarized at each frequency by the following six key statistics. Suppose two time-series $x_1(j)$ and $x_2(j)$ with the crosscovariance $\gamma_{12}(J) = \gamma_{21}(-J)$, then, the cross spectrum is,

$$\hat{S}_{12}(k) = \Delta t \sum_{J=-(N-1)}^{N-1} \omega(J)\gamma_{12}(J)e^{-i2\pi jk/N} = \hat{C}_{12}(k) - i\hat{Q}_{12}(k) \tag{3.10}$$

The crosscovariance is not an even function, thus, the real part $\hat{C}_{12}(k)$ is the cospectrum and the imaginary part $\hat{Q}_{12}(k)$ is the quadrature spectrum. The squared coherency, coherence-squared function, or coherence spectrum estimates between the two time series, and measures the amount that one series can be predicted from the other at different frequencies from which whether two time series share common cycles can be indicated, along with the strength of the contemporaneous relationships. Following Equation (3.10), the coherency can be expressed as:

$$\hat{K}_{12}(k) = \frac{\left|\hat{S}_{12}(k)\right|}{\sqrt{\hat{S}_1(k)\hat{S}_2(k)}} = \frac{\sqrt{\hat{C}_{12}(k)^2 + \hat{Q}_{12}(k)^2}}{\sqrt{\hat{S}_1(k)\hat{S}_2(k)}} \tag{3.11}$$

The cross-amplitude can present a further confirmation by being interpreted as a measure of co-variance between the respective frequency components in the series. The phase or phase difference interprets the lead-lag linkages on the frequency cycles between the two series. In addition, the phase spectrum provides information on the period of time delays between the two time series. Estimating phase is only adding or subtracting an integer number of cycles for the given frequency band. Considering the phase diagram as a whole is the only way that might offset this ambiguity. Usually, phase is defined in frequency terms as degrees or radians:

$$\hat{\Phi}_{12}(k) = \tan^{-1}\left(-\frac{\hat{Q}_{12}(k)^2}{\hat{C}_{12}(k)^2}\right) \tag{3.12}$$

The number of leads can be obtained from $\hat{\Phi}_{12}(k)$>0 or lags from $\hat{\Phi}_{12}(k)$<0 when $x_1(k)$ and $x_2(k)$ in sampling intervals at frequency v_k is given by standardized phase: $phase/(2\pi v_k)$.

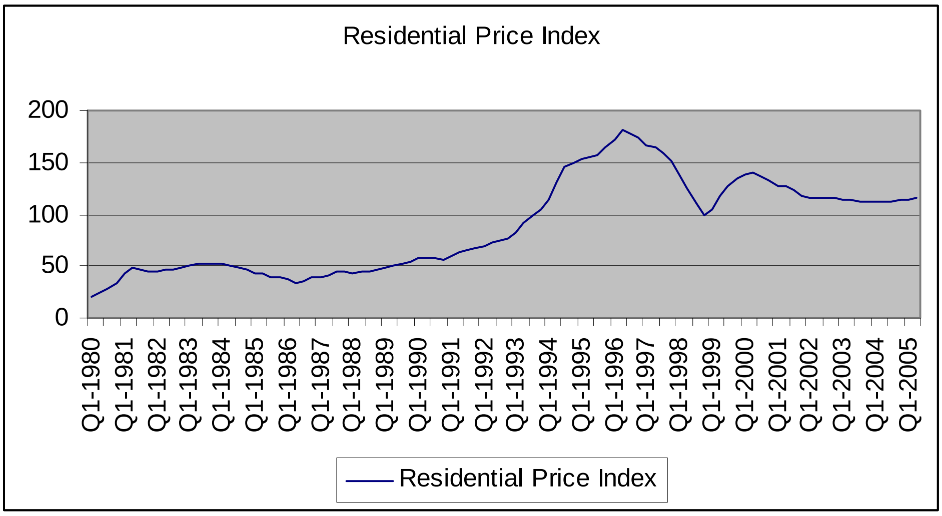
The gain is analogous to the absolute value of the regression coefficient for each decomposed frequency cycle pair (i.e. gain explains how one amplitude is translated into the amplitude of the other) as:

$$\hat{G}_{12}(k) = \frac{\left|\hat{S}_{12}(k)\right|}{\hat{S}_1(k)} \tag{3.13}$$

If a leading or lagging series is referred to, the gain can also indicate the dominance or responsiveness of a series.

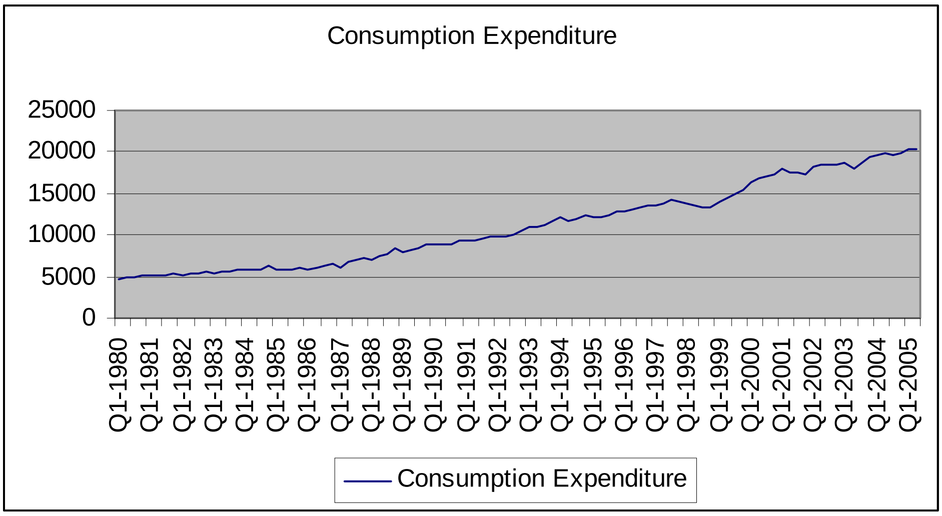
3.4 Data Source and Management

Two time series, housing price and consumption, are required in this study. The quarterly data covering the period from 1980:Q1 to 2005:Q2 are collected from the SingStat Time Series (STS), the Singapore Department of Statistics' web-based time series retrieval system. The private housing price index maintained by the Urban Redevelopment Authority (URA), the physical planning authority of Singapore, provides the data for housing prices. The private housing real estate refers to those built by individuals or private developers on either private or state-tendered land. The reasons for focusing on the private sector are: firstly, the private housing market operates in a laissez-faire economic system within which the housing prices are mainly determined by both the demand and supply in the market (Sing, Tsai, and Chen, 2004); and hence, the interest in this sector stems from the fact that it is subject to the full rigor of market forces, in sharp contrast to the Singapore public sector where state-administered social pricing prevails through subsidies and loans. Secondly, the so-called "upgrading" phenomenon in Singapore makes private housing assets more popular owing to the desire for a new lifestyle, a higher social status, and/or the change of the housing consumption (Tu *et al*., 2005). These reasons enhance the impact of the private housing market sectors on the national economy.



(***Source***: URA, 2007)

NB. the Price Index is computed based on fixed weights before 4th quarter 1998. The weights used to compute the index are updated every quarter from 4th quarter 1998.



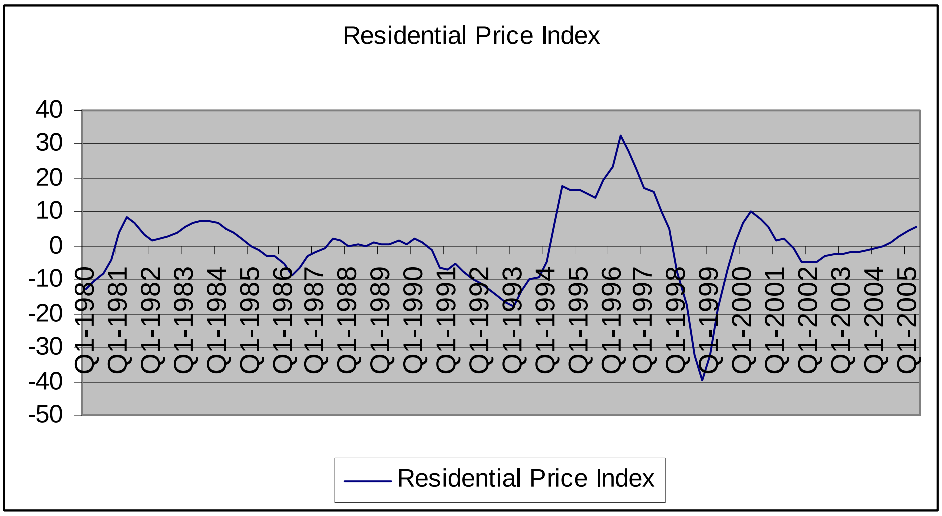
(***Source:*** SDOS, 2007)

NB. the Private Consumption Expenditure on GDP at 2000 market prices (million dollars)

Fig 3.1 Plots of the Original Series

Private consumption expenditure information is selected from the Singapore Department of Statistics (SDOS) Database, under the Ministry of Trade and Industry. However, as Abeysinghe and Choy (2004) report: "Singapore's statistical data on private consumption expenditures are not broken down into spending on consumer durables and non-durable goods and services; hence, I have to model aggregate expenditures without differentiating between these two important categories. Another drawback of using total consumption is that it includes expenditures on housing services in the form of imputed rents on owner-occupied dwellings." The original data is plotted in Fig 3.1.

To facilitate the spectral analysis, all the time series need to be stationary. In practice, however, most economic time series exhibit a clear tendency to grow over time, characterized as "trending". Fig 3.1 provides the evidence of trending in both series. The ADF and PP tests also prove that in Table 3.1. The trending essentially produces a higher order of power at the lowest frequencies and leads to spill-over that distorts the spectrum at higher frequencies, when smoothing the periodogram. To meet the prerequisite of the stationarity, various trend-removal procedures have been well developed like the polynomial regression or the alternative filter way, including the Hodrick-Prescott (HP) filter and first differencing, etc. In this study, the HP filter with $\lambda = 1600$ is selected to detrend the series before the spectra density analysis. The cyclical components of the two series are extracted from the original data set as plotted in Fig 3.2. Further tests on the stationarity show that the null hypothesis of a unit root in each of the detrended series can be rejected at even the 1% significance level (Table 3.1).



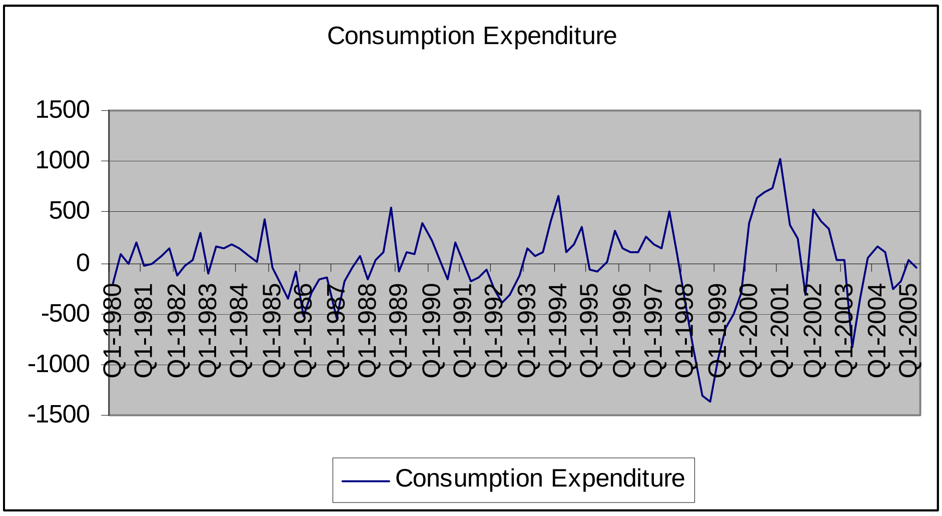


Fig 3.2 Plots of the Series Detrended by HP Filter

Moreover, seasonality tends to produce strong peaks in the spectrum and its harmonics. Therefore, the moving average method is used to conduct seasonal adjustments for the cyclical components of both series. Lastly, considering one series with percentage changes and the other in absolute market value, I normalize the above seasonally adjusted series using the conventional method in order to investigate the cyclical relationships between them. The result is shown in Fig 3.3.

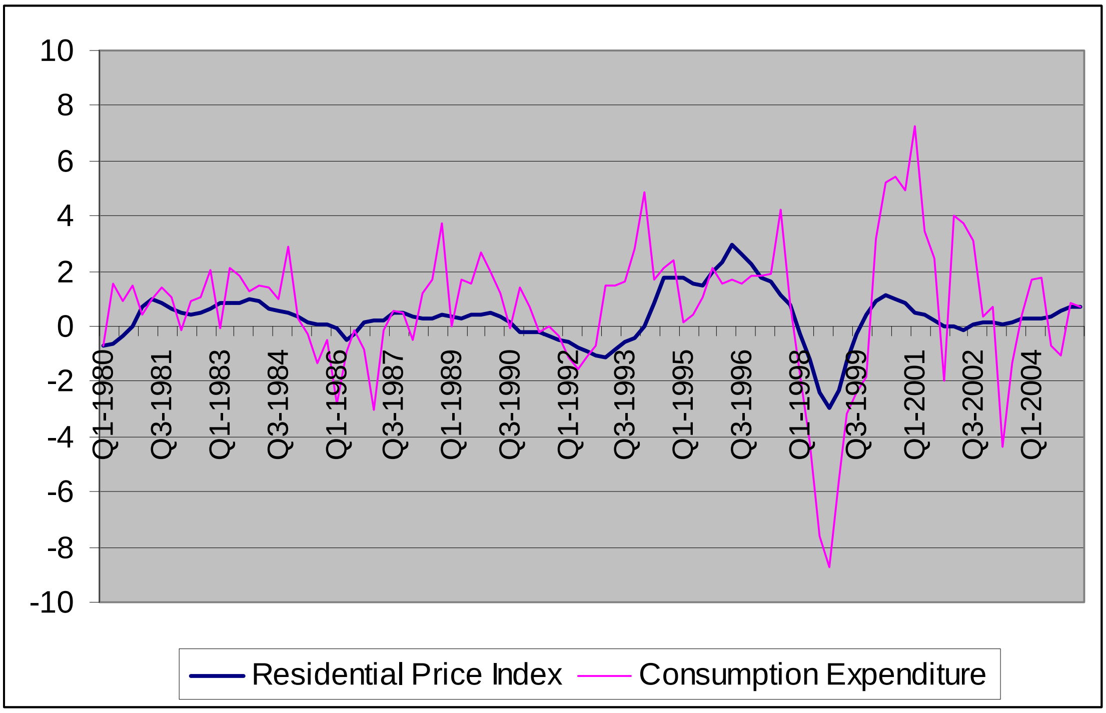


Fig 3.3 Normalized the Seasonally Adjusted Cyclical Components of the Series

Table 3.1 ADF and PP Unit Root Tests for the Original Series and Detrended Series

			Critical Values		
Variable	ADF test	PP test	1%	5%	10%
With Trend and Intercept					
Housing price	-2.351999	-1.493827	-4.052411	-3.455376	-3.153438
Consumption expenditure	-2.070325	-1.995228	-4.051450	-3.454919	-3.153171
No trend and No Intercept					
Detrended housing price	-5.026048	-3.105348	-2.588292	-1.944072	-1.614616
Detrended Consumption expenditure	-4.136989	-4.307206	-2.588059	-1.944039	-1.614637
Lagged difference=8					

3.5 Empirical Results and Analysis

The spectral periodogram and spectra density of two series is plotted in Fig 3.4. The spectral decomposition information extracted from the spectral estimates is summarized in Table 3.2. In Fig 3.4, the periodogram of each series display one main peak and several other smaller spikes. It provides clear evidence that both the housing price and consumption present a dominant cycle and several weak cycle(s) over the period 1980:Q1–2005:Q2. Specifically, as reported in Table 3.2, a major cycle of 25.50 quarters (approximately six years) is identified in the housing price series. The smoothed periodogram value at this frequency band is 33.68%; that is, the long-term cyclical dynamics of the housing price can account for approximately 33.68% of the variation in price return. Similarly, the other four identified minor cycles are 12.75, 10.20, 8.50, and 7.29 quarters, respectively. The weak cycles of these frequency bands lead to the 7.11%, 3.48%, 1.14%, and 1.35% variances, respectively. As observed in both Fig 3.4 and Table 3.2, the smoothed periodogram values of each minor cycle in the housing price series are all smaller than the one of the major cycle, which means that the housing price short-run cycles fluctuate lower than its long-run cycle.

Table 3.2 Spectral Decomposition Information for Both Series: 1980:Q1-2005:Q2

	Housing Price Duration (quarters)	Smoothed Periodogram value	Consumption Duration (quarters)	Smoothed Periodogram value
Major cycle	25.50	0.336771	25.50	0.259908
Minor cycle(s)	12.75	0.071141	17.00	0.13285
	10.20	0.034778	12.75	0.097901
	8.50	0.011356	8.50	0.023289
	7.29	0.013453	6.38	0.037868

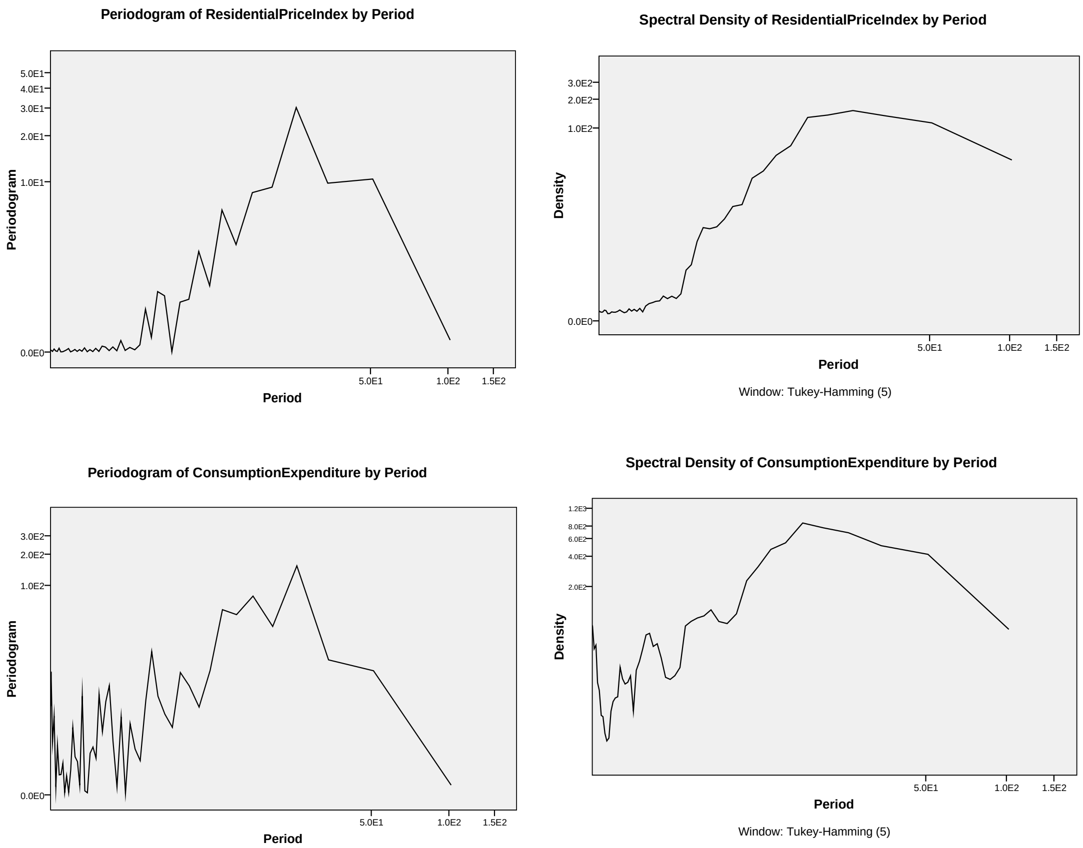
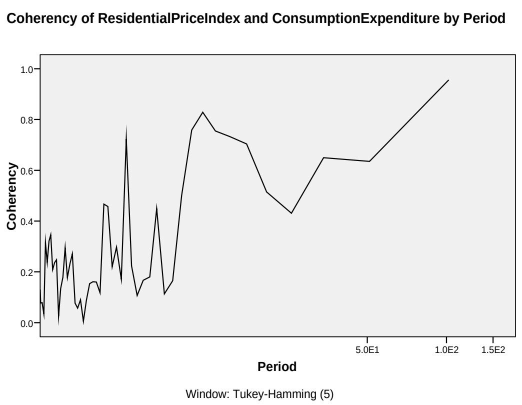
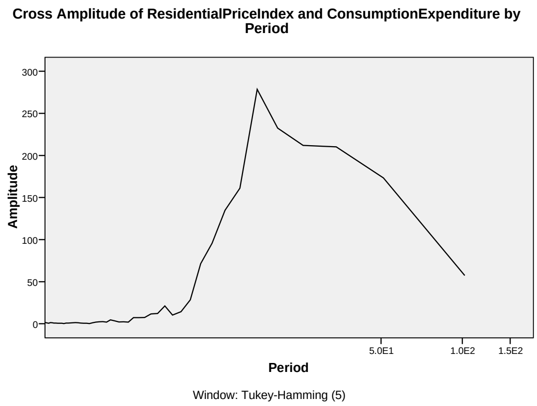


Fig 3.4 Periodogram and Spectra Density of the Two Series

With regard to consumption, the major cycle is also 25.50 quarters, with a variation of the frequency band at 25.99%, which accounts for the cycle. Four minor cycles are shown at 17.00, 12.75, 8.50, and 6.38 quarters, respectively. The variances that account for the weak cycles of consumption are higher than those for housing price, which implies that consumption behaves cyclically more in the short term relative to housing price. On the other hand, the variances accounting for the dominant cycle of consumption are lower than that for housing price, which means that consumption has lower long-run cyclical behavior compared with housing price. Moreover, equal major and minor cycles of the two series implies that there is some kind of strong sensitivity (interrelationships) between their cyclical components. The crossspectral analysis proceeds to confirm this implication from the univariate spectral analysis.

The correlation between the series is first estimated to consolidate the cross-spectral calculations and to ensure that their results are meaningful. The coefficient is 0.572, which is significant at the 0.01 level (2-tailed). It is reasonable and consistent with the foregoing theoretical analysis, which omits the housing loan and truncation cost, etc. To further examine the similarity and codependence between housing price and consumption, coherency is a principal indicator that measures the strength of the interrelationship between the two cyclical components of the two processes at different periods. Fig 3.5 presents the results of the four key statistics along with cross amplitude, phase value, and gain for this pair of series. Table 3.3 reports the Fourier period bands that portray the meaningful contemporaneous or lead-lag patterns between the series.





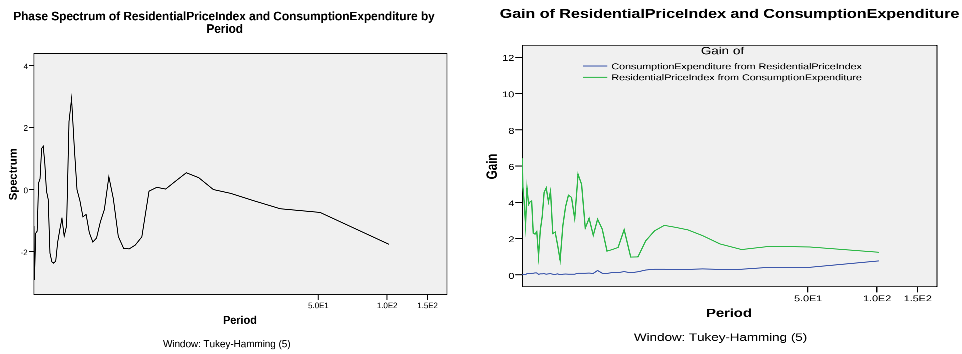


Fig 3.5 Coherency, Cross-amplitude, Phase Spectrum & Gain during the Total Sample Period: 1980:Q1-2005: Q2

Table 3.3 Cross-spectral Statistics of Housing Price and Consumption during the Total Sample Period: 1980:Q1-2005:Q2

Fourier Frequency	Fourier Period*	Coherency	Amplitude	Phase	Gain	Gain**
0.0098	102	0.95566	57.24385	-1.76594	1.24723	0.76623
0.01961	51	0.6351	173.2021	-0.73879	1.53346	0.41416
0.02941	34	0.64936	210.148	-0.62037	1.57189	0.41311
0.03922	25.5	0.43123	211.9175	-0.34814	1.39307	0.30956
0.04902	20.4	0.51477	232.5697	-0.12323	1.70153	0.30253
0.05882	**17**	**0.70367**	**278.6406**	**0.00216**	**2.16171**	**0.32552**
0.06863	14.57143	0.73301	161.0331	0.38053	2.47908	0.29568
0.07843	12.75	0.75496	134.7982	0.54261	2.62249	0.28788
0.08824	11.33333	0.82878	95.54194	0.26274	2.72621	0.30401
0.09804	10.2	0.75851	71.38757	0.01452	2.42818	0.31238
0.10784	9.27273	0.50087	28.47197	0.07023	1.87647	0.26692
0.11765	**8.5**	**0.16492**	**14.23057**	**-0.04957**	**0.98838**	**0.16686**
0.12745	7.84615	0.11301	10.2626	-1.52888	0.98417	0.11483
0.13725	7.28571	0.44926	21.13576	-1.78825	2.48809	0.18056
0.14706	6.8	0.18006	12.18128	-1.91166	1.5084	0.11937
0.20588	4.85714	0.29756	2.21153	-1.04065	3.115	0.09553
0.22549	4.43478	0.45771	3.50967	-1.69049	5.00124	0.09152
0.26471	3.77778	0.16108	2.40619	-0.35608	4.39771	0.03663

0.32353	3.09091	0.07675	0.72812	-1.5088	2.27699	0.03371
0.33333	3	0.27101	1.21496	-0.93426	4.61523	0.05872
0.41176	2.42857	0.23628	0.52083	-0.04265	2.23728	0.10561
0.42157	**2.37209**	**0.2089**	**0.55122**	**0.82781**	**2.29302**	**0.0911**
0.43137	2.31818	0.34616	0.78889	1.39129	4.08328	0.08478
0.44118	2.26667	0.32039	0.76736	1.32455	4.02483	0.0796
0.45098	2.21739	0.23727	1.08758	0.34524	3.88087	0.06114
0.46078	2.17021	0.31489	1.41235	0.21321	4.7885	0.06576
0.5	2	0.26272	1.85803	3.14159	10.32584	0.02544

NB. * Quarters; **Gain from consumption expenditure to housing price index.

Granger and Hatanaka (1964) define the interrelationship between the two cycles as strong if most coherency values are above 0.5 and some above 0.8, moderate if most coherency values range from 0.3 to 0.6, and low if values fall below 0.3. The coherency and amplitude depicted in Fig 53.5 and Table 3.3 therefore demonstrate that there is a strong cyclical relationship between housing price and consumption in the long term (9.27 to 102 quarters) and a weak relationship in the short term (2 to 8.5 quarters). Moreover, the low frequency bands (from 9.27 quarters) depict high coherency values (more than 50%), which indicates that the relationship between the two series is caused by their long-run cyclical dynamics (longer than 9.27 quarters).

In Fig 3.5, it can be seen that the phase values are distributed within both the positive and negative areas alternately before 17 quarters. This implies that the lead or lag relationship between housing price and consumption appear alternately over approximately four years. Beyond four years, the phase values constantly show negative signs, which implies that the housing price slightly lags consumption. More detailed alternate lead-lag patterns are summarized in Table 3.4. Moreover, within the high frequency bands (from 2 to 8.5

quarters), the phase values are higher than those in the low frequency bands. This means that the lead-lag patterns are stronger in the short run than in the long run. Equivalently, the low phase values suggest that most contemporaneous movements occur between the series, especially around the long cycle intervals, which supports the findings from the coherency values. In Table 3.3, the overall Gain values are higher than the Gain** values in the corresponding frequency bands, which implies that housing price modifies consumption. The Gain values of the low frequency bands—from 20.4 to 102 quarters—are lower than those of the high frequency bands, which is consistent with the earlier evidence from the coherency values.

Overall, high coherency values, in general, fall away as frequency increases with alternately negative and positive phase values. Hence, in the long run (more than 9.27 quarters), housing price and consumption are each closely linked and demonstrate clear alternate lead-lag relationships. In the short run (less than 8.5 quarters), the contemporaneous co-movement is weak, although with clear alternate lead-lag patterns. Fig 3.3 is also supports these results. The findings also reveal that consumption leads and lags housing price before 1992:Q1 with longer durations and more co-movement; however, after 1992:Q1, consumption leads and lags housing price with shorter durations and less co-movement.

Due to the different strengths of the contemporaneous relationships in the short and long run that are accompanied by different lead-lag patterns, housing price and consumption perform pro and counter-cyclically to each other, as shown in Fig 3.3. If housing price and consumption are pro-cyclical with high coherency values, the implication is that housing price and consumption positively affect each other. On the other hand, if housing price and consumption are countercyclical with high coherency values, the implication is that the housing price and consumption negatively affect each other. Hence, the alternately positive and negative phase values as shown in Table 3.4 illuminate the possible cyclical nature of housing price on consumption.

Table 3.4 Alternate Lead-lag Relationships between Housing Price and Consumption

Fourier Period Intervals	Phase Values	Lead-lag Relationship
2 to 2.37209	positive	lead
2.42857 to 8.5	negative	lag
9.27273 to 17	positive	lead
More than 20.4	negative	lag

Table 3.5 Granger Causality Test of Housing Price and Consumption (Lags: 4)

Null Hypothesis	F-Statistic	Probability
Housing price does not Granger Cause consumption	3.80748	0.00664
Consumption does not Granger Cause Housing price	1.74877	0.14636

Further results of Granger Causality Tests in Table 3.5 imply that direct Granger causality cannot be established between housing price and consumption. Therefore, there are some underlying factors for the interactions like wealth in the literature. According to Paiella (2007), if wealth is not causal to consumption, then a change in the asset markets will be interpreted as a symptom of a future change in consumer spending rather than a cause. Further, the implications of a sharp correction in asset prices might differ depending on whether a price change causes revisions in the expectations of future economic conditions. Hence, the “expectation effect” in the theoretical model presented here is necessary and makes the theoretical explanation strong enough to capture the association between housing price and consumption.

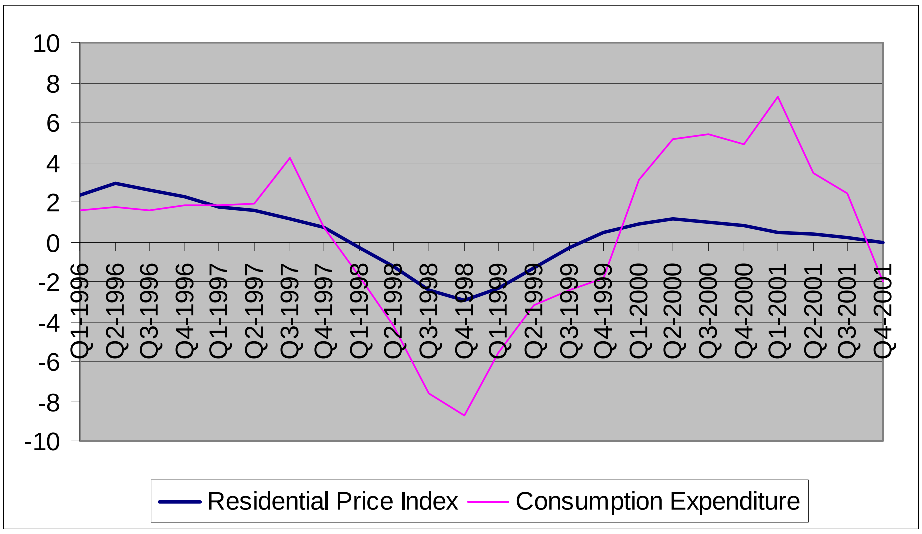


Fig 3.6 A Typical Period: Q1 1996- Q4 2001

In order to distinguish the importance of the capital gain effect from the impact of housing price on consumption, a typical period—from 1996:Q1 to 2001:Q4—was chosen in which to conduct the cross-spectral analysis (Fig 3.6). This period in Singapore is one in which home-buying for consumption or investment turned into speculative behavior. Continued economic growth and increased purchasing power together with a strong sustained upgrading spur speculation by making housing property comparatively superior as an investing instrument to other assets. Daniel (2006) illustrates the phenomena numerically: “From 1986 to 1996, the private housing price index rose by about 440%. About two-thirds of this gain was in the early 1990s up to 1996.” “Over 1992–2002, 58% of the 3-million population changed homes. Among private homeowners, it was almost

70%. This created an upward spiral of property prices that was exacerbated by the speculative elements."

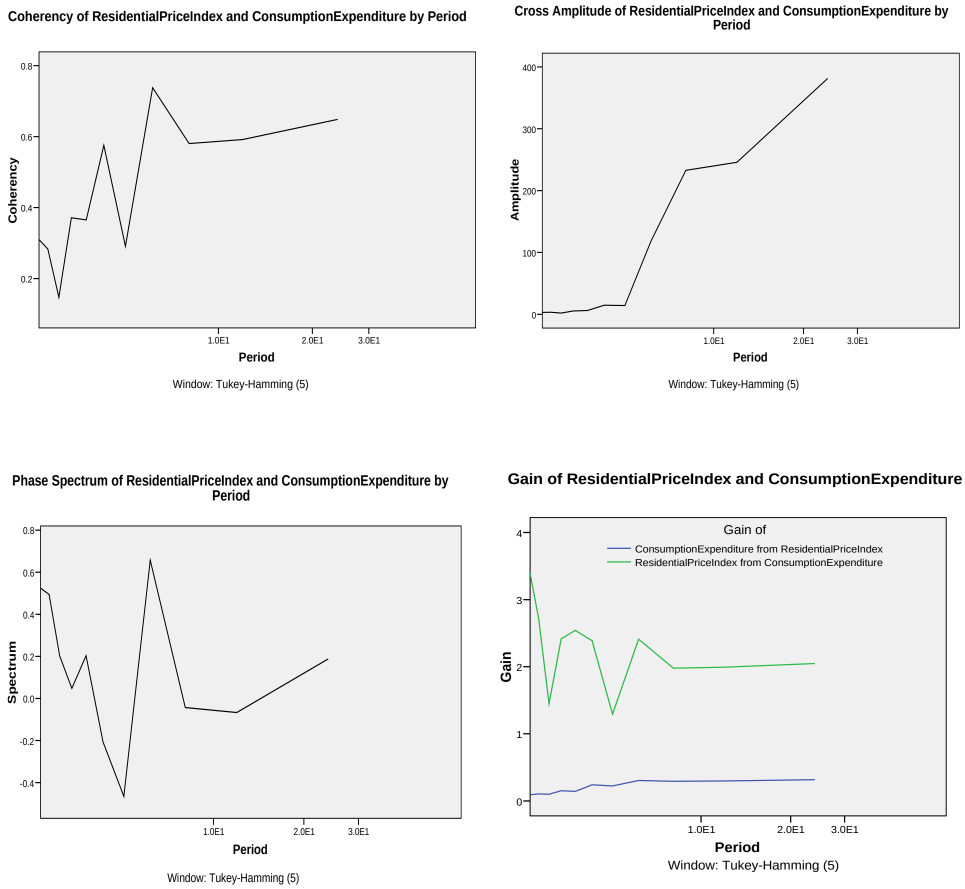


Fig 3.7 Coherency, Cross-amplitude, Phase Spectrum & Gain during a Typical period: 1996:Q1-2001:Q4

The cross-spectral results for the selected period—from 1996:Q1 to 2001:Q4—are presented in Fig 3.7 and Table 3.6. The coherency and amplitude are consistent with the results of the total sample period—small values in short run and large values in long run. Moreover, as expected from the theoretical model, the percentage of the high coherency values is larger than that of the results from the total sample period. In addition, the phase still shows positive and negative signs. However, their values are smaller than those from the total sample period. It also means that housing price and consumption have stronger contemporaneous relationships with slight leads or lags during the typical period than during the total sample period. Furthermore, the Gain and Gain** values of the typical period, in general, are also higher than ones of the total sample period around the corresponding cycle intervals. This indicates that changes in one series during the typical period have more amplitude on the other series than during the total sample period. These findings imply that the capital gain effect is important in explaining the impact of housing price on consumption, especially for the speculative housing market.

Table 3.6 Cross-spectral Statistics of Housing Price and Consumption during a Typical Period: 1996:Q1-2001: Q4

Fourier Frequency	Fourier Period*	Coherency	Amplitude	Phase	Gain	Gain**
0	.	0.62396	457.5827	0	2.08296	0.29956
0.04167	24	0.64831	381.3847	0.18753	2.04781	0.31659
0.08333	12	0.59157	245.6505	-0.06689	1.99246	0.29691
0.125	8	0.58027	232.791	-0.04308	1.97937	0.29316
0.16667	6	0.73768	118.2265	0.65666	2.41156	0.30589
0.20833	4.8	0.29114	14.1097	-0.46525	1.2939	0.22501
0.25	4	0.57549	14.70052	-0.20687	2.38987	0.2408
0.29167	3.42857	0.36555	6.12273	0.20301	2.54215	0.14379
0.33333	3	0.37113	5.45966	0.04819	2.41648	0.15358
0.375	2.66667	0.14716	2.09902	0.20188	1.45025	0.10147
0.41667	2.4	0.28321	3.28348	0.49443	2.72288	0.10401
0.45833	2.18182	0.31252	3.07827	0.52651	3.44755	0.09065
0.5	2	0.15401	2.18874	0	2.09525	0.0735

NB. * Quarters; **Gain from consumption expenditure to housing price index.

The typical period is separated into a recession period (1996: Q1–1998:Q4) and an expansion period (1999:Q1–2001:Q4) to investigate whether the ambiguous sign takes into account the capital gain effect (Fig 3.6). The results of the cross-spectral analysis for both periods are reported in Fig 3.8 and 3.9 and Tables 3.7 and 3.8. As shown in Table 3.7 and 3.8 for the corresponding frequency bands, the coherency and amplitude values of the recessionary period are higher than those of the expansionary period. In addition, the phase values of the recessionary period are lower than those of the expansionary period. Hence, coherency, amplitude, and phase provide clear evidence that in the recessionary period, housing price and consumption have more contemporaneous cyclical movements than in the expansionary period. This implies that consumers are more sensitive to the housing market during recessionary periods than during periods of expansion. Referring to the gain, it is smaller in the recessionary period than in expansionary period around the corresponding intervals. Hence, these findings are consistent with the hypothesis based on the theoretical model. The expectation effect operating through the capital gain effect during the expansionary period is larger than the one during the recessionary period. Consequently, the changes of consumption caused by the changes of housing price show positive or negative in different frequencies with alternate expansion and recession along the housing price cycle.

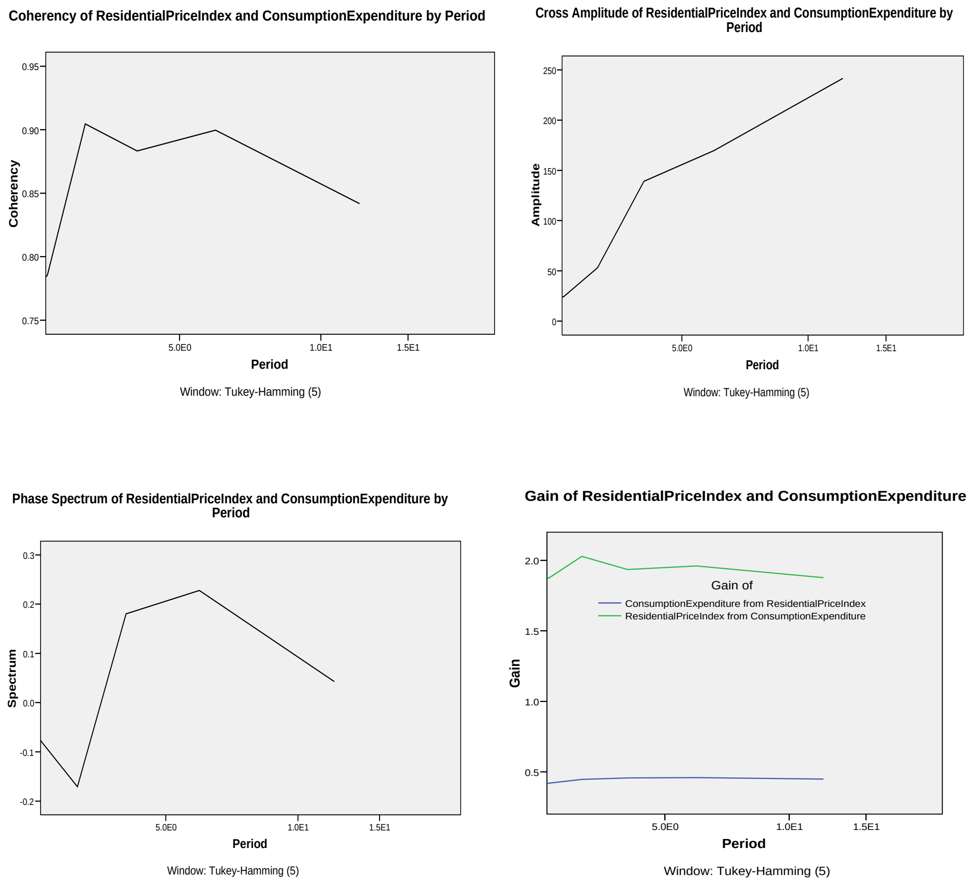
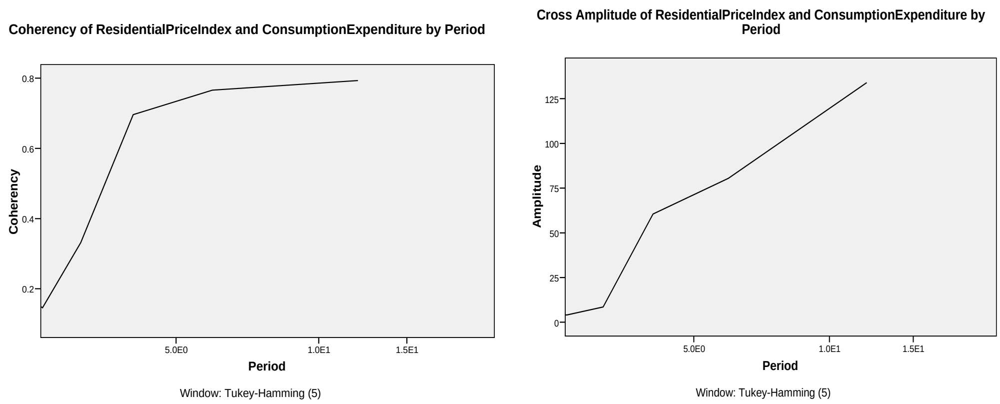
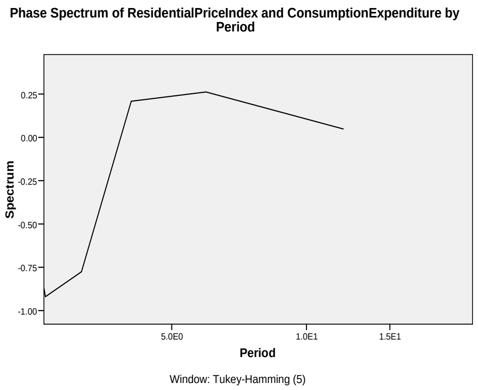


Fig 3.8 Coherency, Cross-amplitude, Phase Spectrum & Gain in the Recession Period: 1996:Q1-1998:Q4





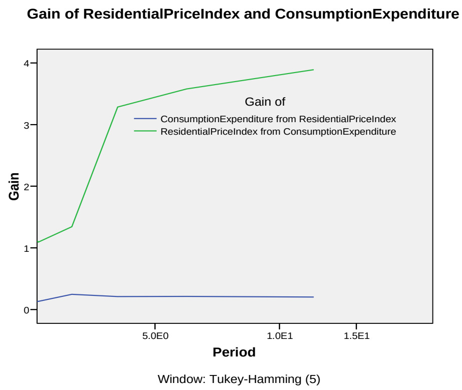


Fig 3.9 Coherency, Cross-amplitude, Phase Spectrum & Gain in the Expansion Period: 1999:Q1- 2001:Q4

Table 3.7 Cross-spectral Statistics of Housing Price and Consumption in the Recession Period: 1996:Q1-1998:Q4

Fourier Frequency	Fourier Period*	Coherency	Amplitude	Phase	Gain	Gain**
0	.	0.84286	269.5939	0	1.89229	0.44542
0.08333	12	0.84182	241.5296	0.04263	1.8768	0.44854
0.16667	6	0.89971	169.664	0.22754	1.95998	0.45904
0.25	4	0.8833	139.1634	0.18039	1.93472	0.45655
0.33333	3	0.90449	53.06665	-0.17071	2.02861	0.44587
0.41667	2.4	0.78529	24.21359	-0.08092	1.87268	0.41934
0.5	2	0.76277	22.572	0	2.09862	0.36346

NB. * Quarters; **Gain from consumption expenditure to housing price index.

Table 3.8 Cross-spectral Statistics of Housing Price and Consumption in the Expansion Period: 1999: Q1-2001:Q4

Fourier Frequency	Fourier Period*	Coherency	Amplitude	Phase	Gain	Gain**
0	.	0.81829	148.5795	0	3.92735	0.20836
0.08333	12	0.79348	134.0009	0.0477	3.88919	0.20402
0.16667	6	0.76598	80.44973	0.26251	3.57813	0.21407
0.25	4	0.69609	60.52988	0.20831	3.28572	0.21185
0.33333	3	0.3314	8.55551	-0.77582	1.34413	0.24655
0.41667	2.4	0.14609	4.06949	-0.91902	1.09494	0.13342
0.5	2	0.20491	4.68753	0	1.43512	0.14278

NB. * Quarters; **Gain from consumption expenditure to housing price index.

3.6 Summary

This Chapter establishes the cyclical housing prices-consumption association TFA for this dissertation's study on housing market dynamics and its commonalities. It investigates private consumption changes that are brought about by the housing price effect, which in turn is envisaged to comprise the income effect, substation effect, and expectation effect along with the housing price cycle.

Based on this TFA, an empirical study on the association between housing price and consumption from a cyclical perspective is conducted through the use of spectral and cross-spectral density models. In order to obtain the in-depth understanding of such association, the Singapore private housing market is selected. Its large boom-bust fluctuations make it a meaningful market to be investigated during the total sample period (1980:Q1-2005:Q2), even during a typical period (1996:Q1-2001:Q4), and even more detailed periods (1996:Q1-1998:Q4) and (1999:Q1-2001:Q4).

In terms of the total sample period, the spectral analysis shows that both housing price and consumption experience a major cycle at approximately 25.5 quarters (more than six years), with variations of 33.68% and 25.99%, respectively. Compared with consumption, housing price performs cyclically and stronger in the long run. According to the cross-spectral analysis and where low frequencies (from 9.27 to 102 quarters) indicate that the mid and long run demonstrate relatively high coherency, then in the mid and long run, housing price and consumption are closely linked and show clear alternate lead-lag relationships. High frequencies (from 2 to 8.5 quarters) indicate the short run, where there is weak evidence for cyclical relationships between the two series in the short run, albeit with a clear alternate lead-lag pattern. Such lead-lag pattern keeps consistent with the one from the typical period. Furthermore, direct Granger causality cannot be established between housing price and consumption.

To summarize, the statistical results from all selected periods are consistent with the theoretical explanation (i.e. that the expectations effect plays an important role in explaining the housing price-private consumption association). In addition, the housing price affects consumption significantly depending on the time scale and frequency without a consistent sign (i.e. if the expectation effect is larger than the sum of both income effect and substitution effect during the expansion period, then housing prices affect consumption positively; if the expectation effect is not enough to cover both income effect and the substitution effect during the recession period, then the impact is negative). Owing to the inherent model-free charlatanistic cross-spectral analysis, the results avoid the error from the model misspecification and are independent of the causal effect of housing price on consumption.

The findings for Singapore from a cyclical perspective are inconsistent with those of Lettau and Ludvigson (2004) and Chen (2006). There are three possible reasons for this inconsistency. First, the coefficients in the VECM deployed in their studies are constant for each lag (i.e. it is assumed that they adjust back to equilibrium at a constant pace). However, the generalized autoregressive conditional heteroscedasticity (GARCH) model widely used in financial market studies relaxes this assumption of constant error variance.

It is also applies to analyzing house price volatilities (e.g., Chinloy *et al*., 1997; and Guirguis and Vogel, 2006). In addition, the empirical characteristics of the housing price-consumption issue highlight different channels through which housing price affects consumption. Some effects from these different channels are consistent while some are competing. Which effect(s) dominates or what is the integrated effect is an empirical issue, depending on the different dataset within the different time span for the different area. Second, as mentioned, drawbacks exist in Singapore's statistical data on private consumption expenditures and the calculations of total consumption, so that increases in house prices will cause consumption to rise independently of any wealth effect (Abeysinghe and Choy, 2004). Finally, another reason lies in a theoretical explanation. Macroeconomic estimation, as suggested by Andrew and Meen (2003), needs to be complemented by careful microeconomic analysis. In the current research, the housing price-consumption issue is explained by individual expectation effects in the pursuit of optimization, following persistent housing price cycles.

CHAPTER 4 HOUSING MARKET DYNAMICS WITHIN A DYNAMIC FACTOR APPROACH

4.1 Introduction

Housing not only accounts for a large share of most households' expenditure; it is also the household's main liability (its mortgage debt). Through affecting households' net wealth and capacity to borrow and spend, housing plays a significant role in the economy. Chapter 3 provides the empirical evidence on the housing prices-consumption channel. Moreover, the resulting conclusion based on the first TFA is that investors' expectations play the integral role in explaining the association of housing price dynamics with private consumption. Such a conclusion accentuates the pervasive inefficiency, illiquidity and disequilibrium of the housing market.

This Chapter further extends the housing price-consumption channel to a wider perspective to investigate housing market dynamics, with the view that housing is an imperative sector in the whole economy. The Chapter seeks to offer the economic interpretation and estimate housing market dynamics through highlighting its special features (inefficiency, illiquidity disequilibrium and business cycle features). Under general equilibrium theory and the Walrasian attunement process, housing market dynamics is attributable to continuous and systematic adjustments between equilibrium and disequilibrium processes. It is discussed at some depth in Section 4.2.

Schulz and Werwatz (2004) have developed a hedonic model by connecting it to economic theory. They estimate an empirical model that relates housing prices to observable characteristics (i.e. the cross-section dimension) and an unobservable price component (i.e. the time-section variation dimension). Motivated by their study and rooted in the economic interpretation under the general equilibrium framework, the study in this Chapter focuses on housing market dynamics driven by a small number of fundamental unobservable common factors, and the time-series variation in housing prices. The resulting lines of inquiry from such research objectives can be investigated under a generalized dynamic factor model (GDFM) framework (see Forni, Hallin, Lippi and Reichlin, 2000; 2004).

Section 4.3 introduces the GDFM, including its advantages, specification and the criterion selections under its framework. This is followed by the definition of commonality and the common components in Section 4.4. The Singapore private housing market is corresponding examined, the data and its treatment are introduced in Section 4.5. In Section 4.6, the empirical results are analyzed. Other three data panels taking into account the time-dimension and the cross-dimension are robust tested in Section 4.7. Section 4.8 concludes the research in this Chapter.

4.2 Theoretical Work

A Systematic Perspective: General Equilibrium

Housing price has been extensively documented and in particular the "…declines in nominal house prices are relatively rare although the volume of housing market transactions tends to be more responsive to a slowing economy. A flattening out of an observed price series may in fact mask a buildup of inventory of unsold houses" (Krainer, 2002, page 1). "House prices are sticky downward and characterized by inertia, and it is unlikely that an economic downturn would lead to a precipitous decline in home values" (Case *et al.*, 2000, page 144). This phenomenon is demonstrated by Leamer (2007) to be akin to the housing volume cycle rather than the price cycle in explaining the importance of housing during a recession. A consistent issue that can be explored relates to the liquidity aspect, as alluded by Krainer (2001, page32), who reiterates that "changes or shocks to the fundamental value of housing are not transmitted solely through market prices but through market liquidity as well".

Moreover, the inertia or the momentum in real housing price changes (also defined as "persistence" by Krainer, 2002) indicates an inefficient market "either in the sense that the market takes time to clear or that prices and expectations of future price changes are set in a backward-looking manner". "An alternative explanation for the persistence in house prices is that prices depend directly on economic variables, such as job growth and changes in personal income, that are themselves persistent". Thus, with regard to the illiquid housing market, prices would be construed as systematic mispricing. "We should not, in general, expect changes in fundamental values to be accompanied by equal changes in market prices" (Krainer, 2001). Sales volumes and inventories are characterized as reliable predictors of downturns in Krainer (2006). Hence, "it is best to consider economy-wide factors in addition to specific housing market variables when evaluating the real estate market", and to consider that the "incoming information from the housing market should be evaluated in the context of the overall economy's performance" (Krainer, 2006).

Hence, in the second TFA of the dissertation, housing market activities are measured from a systematic perspective taking into account the reasonable cross-sector dimension, based on general equilibrium theory. Housing price fluctuations are driven by two factors, namely, the macro-economy conditions and the intrinsic characteristics of the housing market with due consideration of the returns on other asset classes. The general equilibrium model of Raberto *et al.* (2006) is augmented to simply explain housing market activity that is interrelated with other sectors of the economy. The model is characterized by three agents: a representative firm (including developers), the heterogeneous household and the government. Housing real estate is deemed to be an asset in this model since the study by Dusansky and Koc (2006) alludes the housing role to be an asset with its potential for capital gain dominating its role as a consumption good for housing demand. Specifically, at each time t, the heterogeneous household i provides the labor supply $L_{i,t}^{s}$ to the representative firm and demands consumption goods $C_{i,t}^{d}$ based on his utility maximizing behavior. Households are myopic and their utility function is two-period and time-separable, determined by the current and expected leisure and consumption streams:

$$U_{i.t} = u(C_{i,t}, \ell_{i,t}) + E_{i,t}u(C_{i,t+1}, \ell_{i,t+1}) \tag{4.1}$$

, where at each time t, $E_{i,t}$ is the expected value and leisure ℓ_i is obtained from $\ell_i = L_{\max} - L_i$, $L_{\max}$ is the maximum working hours that the household can provide.

Supposed household is unemployed at time t+1, the household then set his schedule of L_i^s and C_i^d by maximizing his intertemporal utility, subject to a budget constraint in Equation (4.4).

i.e. $$\max_{C_{i,t}^d, L_{i,t}^s} U_{i,t} = a \log C_{i,t}^d + c \log(1 - \frac{L_{i,t}^s}{L_{\max}}) + bE_{i,t} \log(\frac{\hat{W}_{i,t+1}}{p_{t+1}}) \quad (4.2)$$

With $$\hat{W}_{i,t+1} = (1 + \rho_{i,t+1}) \hat{\Pi}_{i,t} \quad (4.3)$$

$$\hat{\Pi}_{i,t} = W_{i,t} - p_t C_{i,t}^d + w_t L_{i,t}^s + n_t R_{i,t} + n_t A_{i,t} + r_t B_{i.t} - T_{i,t} \quad (4.4)$$

, where a, c and b are the relative weights of the utility of present consumption, leisure, and of expected utility of real wealth in the next period, respectively. $W_{i,t}$ is the nominal wealth at time t, $p_t C_{i,t}^d$ is the money paid for the desired amount of goods, $w_t L_{i,t}^s$ is the salary received from the desired labor supply. Since real estate returns comprise two portions: the rental return and the capital appreciation, $n_t R_{i,t}$, $n_t A_{i,t}$ denote the housing rental income and housing capital gain from *n* housing assets (properties) held by household i at time t. $r_t B_{i.t}$ is the interests paid by government bonds. $T_{i,t}$ is the nominal tax paid to the government.

Equation (4.3) states the expected dynamics of wealth by reinvesting money amount $\hat{\Pi}_{i,t}$ in the housing asset and in the bond at an unknown stochastic rate $\rho_{i,t+1}$. Household is supposed to behave without considering possible rationing and to only consider notional demand and supply schedules, $C_{i,t}^{d}$, $L_{i,t}^{s}$, for his wealth dynamics. Such notional schedules are obtained by solving the problem as stated in Equations (4.2) - (4.4).

$$C_{i,t}^{d} = \frac{a}{a+b+c}\frac{w_t}{p_t}L_{\max} + \frac{a}{a+b+c}\frac{W_{i,t} + n_t R_{i,t} + n_t A_{i,t} + r_t B_{i.t} - T_{i,t}}{p_t} \tag{4.5}$$

$$L_{i,t}^{s} = \frac{a+b}{a+b+c}L_{\max} + \frac{c}{a+b+c}\frac{W_{i,t} + n_t R_{i,t} + n_t A_{i,t} + r_t B_{i.t} - T_{i,t}}{w_t} \tag{4.6}$$

, where a, b, c and $L_{\max}$ denote the household preferences.

In terms of the asset markets, household is supposed to allocate the amount $\hat{\prod}_{i,t}$ in the housing asset and in a financial asset, like the bond. If $\omega_{i,t}^{H}$, $\omega_{i,t}^{B}$, which denote the portfolio weights of two kinds of assets, respectively, according to Markowitz's modern portfolio theory (1952):

$$\omega_{i,t}^{H} + \omega_{i,t}^{B} = 1,\ \omega_{i,t}^{H} = \frac{r_{i,t}^{H} - r_t^{B}}{\gamma_i(\sigma_{i,t}^{H})^2} \tag{4.7}$$

, where $r_{i,t}^{H}$ and $\sigma_{i,t}^{H}$ are the expected housing asset return and volatility respectively. According to Dolde and Tirtiroglu (2002), "the return on an owner-occupied house in any period comprises the implicit income yield and the percentage price change. It is a rare data set that is sufficiently comprehensive to permit estimation of the income yield, thus, as in much of housing return research, we must work with the price change component alone. It seems likely, however, that, as with many other assets, the variability of housing returns is largely due to price fluctuations. Capozza and Seguin (1989) indicate that price change volatility dominates the total housing return volatility even in decennial data.” Therefore, $r_{i,t}^{H}$ and $\sigma_{i,t}^{H}$ can be imputed from the method of Raberto (1999) where r_t^B is the assumed risk free interest rate on government bonds. γ_i is the specific risk aversion parameter to household i. The demand of the housing asset $H_{i,t}^{d}$ and the financial asset $B_{i,t}^{d}$ is expressed in Equation (4.8).

$$H_{i,t}^{d} = \omega_{i,t}^{H}\Pi_{i,t};\ B_{i,t}^{d} = \omega_{i,t}^{B}\Pi_{i,t}. \tag{4.8}$$

As for the firm, it can be an accommodation provider who produces consumption goods and develops housing assets. The goods supply C^s and labor demand L^d of the representative firm are subjected to a Cobb–Douglas production technology function in that labor L is assumed to be the only input of production, $C = \alpha L^{\beta}$. α , β are constant with $\alpha > 0$, $0 < \beta < 1$. C^s and L^d set by maximizing the expected profits π_t^e:

$$\max_{Y^S, L^d} \pi_t^e = p_t C_t^s - w_t L_t^d \tag{4.9}$$

where p_t and w_t are the given price and the nominal wage per unit of labor at time t, respectively. The notional schedules for C^s and L^d can be obtained as

$$C_t^s = \alpha^{1/(1-\beta)}\beta^{\beta/(1-\beta)}(\frac{w_t}{p_t})^{\beta/(\beta-1)} \tag{4.10}$$

$$L_t^d = (\alpha\beta)^{1/(1-\beta)}(\frac{w_t}{p_t})^{1/(\beta-1)} \tag{4.11}$$

The government collects taxes T_t from the household and pays interests on the bond $B_{.t}$. Hence, the bond supply is given by $B_{t+1}^s = B_t^s + \delta_t D_t$, where $\delta_t D_t$ denote the deficit covered by issuing new bonds. Then, the price vector p, w that characterizes the real sector of the economy at Walrasian equilibrium is obtained by the equilibrium of the goods and labor markets:

$$w_t^{Walrasian} = \frac{\beta a + c}{\zeta L_{\max}(a(1-\beta)+b)}(W_{i,t} + n_t R_{i,t} + n_t A_{i,t} + r_t B_{i.t} - T_{i,t})$$

(4.12)

$$p_t^{Walrasian} = a(\frac{\beta a + c}{\zeta L_{\max}\beta a})^{\beta} \frac{(W_{i,t} + n_t R_{i,t} + n_t A_{i,t} + r_t B_{i.t} - T_{i,t})}{(a(1-\beta)+b)} \quad (4.13)$$

$$L^{Walrasian} = \alpha^{1/(1-\beta)}(\frac{\zeta L_{\max}}{1 + c/\beta a}) \quad (4.14)$$

$$C^{Walrasian} = \alpha^{1/(1-\beta)}(\frac{\zeta L_{\max}}{1 + c/\beta a})^{\beta} \quad (4.15)$$

According to eq (4.12), (4.13), the capital gain of each housing asset under the Walrasian equilibrium can be

$$A_{i,t} = \frac{\zeta L_{\max}(a(1-\beta)+b)w_t^{Walrasian}}{n_t(\beta a + c)} - \frac{W_{i,t} + n_t R_{i,t} + r_t B_{i.t} - T_{i,t}}{n_t} \quad (4.16)$$

$$A_{i,t} = \frac{p_t^{Walrasian}(a(1-\beta)+b)}{n_t a}(\frac{\beta a + c}{\zeta L_{\max}\beta a})^{-\beta} - \frac{W_{i,t} + n_t R_{i,t} + r_t B_{i.t} - T_{i,t}}{n_t}$$

(4.17)

Then, according to eq (4.14), eq. (4.16) can be expressed as

$$A_{i,t} = \frac{(1 + c/\beta a)(a(1-\beta)+b)w_t^{Walrasian} L^{Walrasian}}{n_t(\beta a + c)\alpha^{1/(1-\beta)}} - \frac{W_{i,t} + n_t R_{i,t} + r_t B_{i.t} - T_{i,t}}{n_t}$$

(4.18)

According to eq (4.15), eq (4.17) can be expressed as

$$A_{i,t} = \frac{C^{Walrasian}(a(1-\beta)+b)p_t^{Walrasian}}{n_t a \cdot \alpha^{\beta/(\beta-1)}} - \frac{W_{i,t} + n_t R_{i,t} + r_t B_{i.t} - T_{i,t}}{n_t}$$

(4.19)

Therefore, the above general equilibrium model demonstrates that housing price dynamics depends on the goods market (i.e. the goods price $p_t^{Walrasian}$, the output $C^{Walrasian}$), the labor market (i.e. the nominal wage, $w_t^{Walrasian}$, employment $L^{Walrasian}$), the asset market (i.e. interest rate on bond and the bond price, $r_t B_{i.t}$) as well as other factors such as wealth, housing rental income and government taxes. Moreover, the dynamics also relate to factors such as household's preferences (a, b, c and $L_{\max}$) and technology (α, β).

A General Disequilibrium Perspective

The oligopolistic real estate market (Shilling and Sing, 2006) makes price and quantity less volatile than they would be in a complete (perfect) market (Black, 1995). Owing to the incomplete market, market illiquidity and the slow responses of investors to market news, housing transaction prices and appraisals generally reflect changes in market conditions and fundamentals with time lags rather than instantaneous changes. Such lags in housing price responses to market news make the observed price indices less informative and they hinder an accurate measurement of housing market performance (see Fu, 2003; Fu and Ng, 2001). Such slow adjustments and continuous disruption in the housing market imply a sustained disequilibrium market that almost never clears (Riddel, 2004). Anas and Eum (1984) test the disequilibrium adjustment process in housing market activity based on an extension of the standard hedonic model. Their results indicate that the disequilibrium specifications help better pricing. Additionally, Riddel (2004) models housing market disequilibrium to examine housing price and its stock dynamics based on the stock-flow model, and he reports "The sustained periods of disequilibrium" in the U.S. housing market. Extending Riddel's idea to the general equilibrium model can then express the Walrasian attunement process as:

$$p_{t+1} = p_t \exp(k_p(\sum_i C_{i,t}^d - C_t^s))$$

(4.20)

$$w_{t+1} = w_t \exp(k_w(L_t^d - \sum_i L_{i,t}^s)) \qquad (4.21)$$

$$A_{t+1} = A_t \exp(k_H(\sum_i H_{i,t}^d - H_t^s))$$

(4.22)

, where, k_p , k_w and k_H are disequilibrium sensitivities. H_t^s is the housing asset supply at time t. The bond market is supposed to clear instantaneously while prices p , w and housing prices do not move instantaneously to their clearing values. The price-adjustment process is represented by Equations (4.20) - (4.22) and it mimics housing market dynamics in terms of the disequilibrium between aggregate notional demand and supply, based on a sequence of quantity-constrained equilibria. Such a neoclassical approach to housing price dynamics supposes that price returns to equilibrium at a rate that is proportional to the extent to which it is out of equilibrium. However, it is based on three idealizations. According to Caginalpa and Merdan (2007), firstly the housing (asset) demand and supply are determined by their own values. In reality, the diverse motivations of investors, for e.g., the momentum effect, acts as a violation. Secondly, a unique price determined by the set of all available information is not satisfied by an important aspect of housing price dynamics that involves the interaction between two or more groups with differing valuations and different strategies as well as their differing resources. Thirdly, the efficient assumption would require an infinite amount of "arbitrage" capital that is ready to exploit any deviations from the realistic price. This is apparently not met in practice in the housing market. In reality, housing price dynamics would be more complex than the price-adjustment process of Equations (4.20) - (4.22).

The Housing Market Dynamics Framework

The familiar four-quadrant model of DiPasquale and Wheaton (1992, 1996) illustrates housing market dynamics via an adjustment process to changes in three interrelated markets, i.e. the space (rental) market, the capital (asset) market and the construction (development) market. Keeping consistency with this model, Sing (2001) refers to the "residential capital market" in order to capture the growing role of houses as real assets, compared to the "residential space market" that focuses on the role of houses as durable goods. The interaction between both markets is highlighted to investigate the key relationships between supply and demand holistically. Referring to Sing (2001) and Liu and Shen (2005)[19], the foregoing simple general equilibrium model are framed and extended by considering two more agents, i.e. financial institutions and housing

[19] They provide a theoretical mechanism between real estate prices and economic fundamentals taking into account three kinds of agents, namely households, companies and financial institutions.

developers[20]. The former fulfills the mission of providing real estate mortgage loans to finance firms and households. Banks and other financial institutions play an important role in the housing capital market in the securitization of housing real estate that acts as an alternative investment vehicle for institutional investors. Such securitization improves housing market liquidity and it serves as an alternative way to raising capital funding for both developers and direct (private) real estate owners. Since construction usually lasts a long lag period to complete a new building, developers rely on their better accessibility to cost information to arbitrage on short-term price variations in the market or to occasionally misjudge the real estate cycle. Such arbitrage is an important link between the "residential space markets" and "residential capital markets" (Sing, 2001).

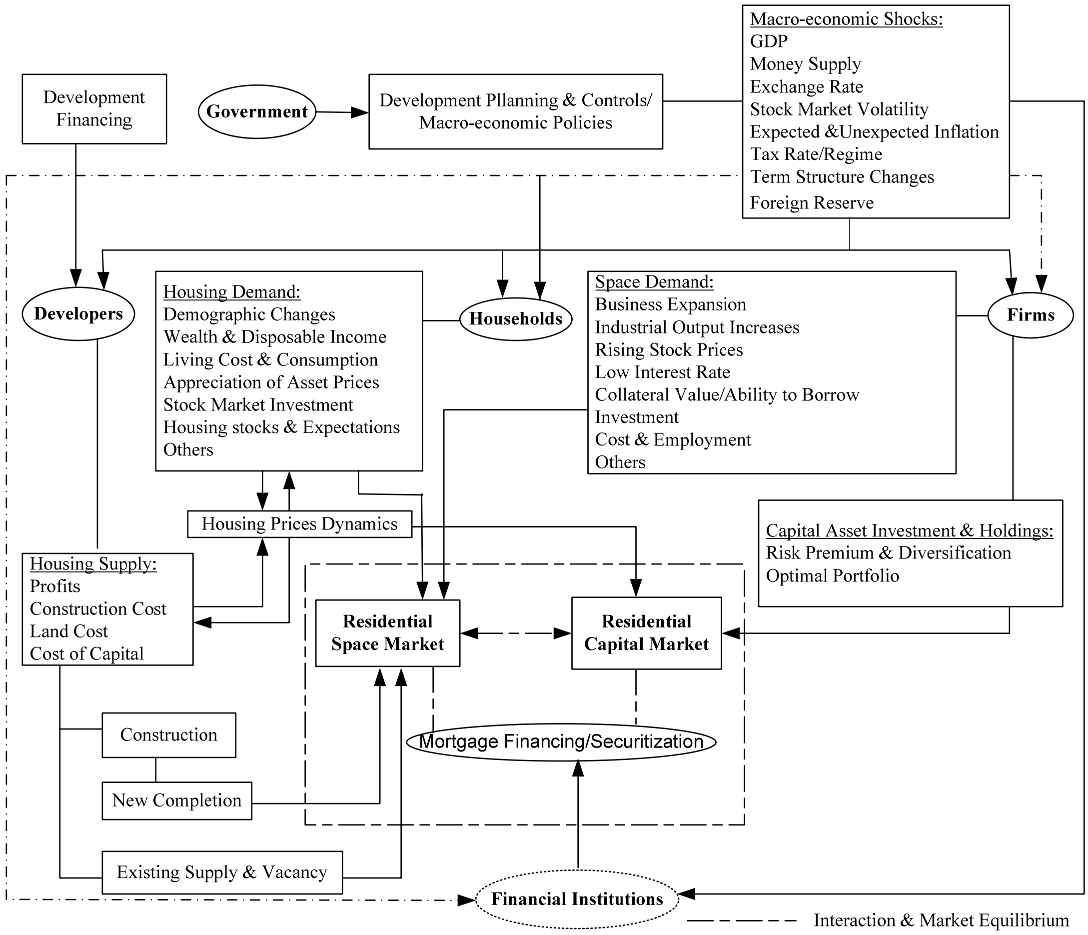
Hence and according to the appropriate literature, a theoretical structure is illustrated in Fig 4.1 to explain housing market dynamics rooted in general equilibrium theory from a systematic perspective. Such a theoretical structure takes into account the dual features of housing as a durable good and as a real asset and it concerns the recurrent interactions between and among several sectors, when considering housing price dynamics via changing levels of housing demand and supply as well as the securitization instruments[21][22]. The interaction between the housing market and the other markets

[20] Sing (2001) provides detailed explanation on the roles and relationships among the other three agents, namely government, firms and households during the macro-economy's boom.

[21] Usually, the impact of other sectors on housing prices is studies. The opposite causation, i.e. the effect of real estate price dynamics on the macroeconomic performance draws researchers' attention especially during the economy contraction period, for e.g. Quigley (2001) and Kim (2000), and is also investigated in Liu and Shen (2005).

[22] See Chapter 2 for the detailed review on the impact of housing dynamics on consumption and Chapter 3 for the empirical investigation on the cyclical association of housing price and consumption.

(sectors) drive housing price to slowly adjust towards the equilibrium level together with a sequence of equilibriums in other sectors. Such an interactive process embodies the lead and/or lag cyclical dynamics among the housing market–specific variables, such as transaction volume, housing price and construction, with changes in the housing market or in the economy's conditions. Accordingly, various demand and supply shifts pertaining to housing market dynamics can be identified.



(***Source***: Sing, 2001; author, 2008)
NB. The developers are space provider including landlords; the firms are space occupiers.

Fig 4.1 Theoretical Structure of Housing Market Dynamics

The Business Cycle Feature of the Housing Sector

"Housing is the business cycle" as titled by Leamer (2007) and he offers a detailed demonstration of his strong view. However, no macroeconomic textbook has placed real estate at the forefront or center stage as such nor has the real world done so. This would include for example, the NBER macroeconomic data mining that has largely missed out housing sector and its cycles. The housing sector, as an imperative component of the entire economy, possesses a special characteristic in comparison to other sectors. The fact that housing takes on the business cycle feature can be explained by its dual roles as a durable good with a heterogeneous location and as a long-lived real asset, in conjunction with the unique characteristics of the housing market, i.e. being inefficient, illiquid while incurring large-sized transactions and involving cross disciplinary fields of inquiry. Therefore, housing market dynamics would ultimately exhibit business cycle features and can be investigated under the business cycle theory. According to Lucas (1977), the business cycle is indicative of economy-wide conditions and it is defined as the repeated fluctuations in employment, output and the composition of output, that are associated with a certain typical pattern of co-movements in prices and other variables. The business cycle also represents the main qualitative features of economic time series. Technically, the movements around a trend can be expressed as a stochastically disturbed difference equation of very low order. Although these movements are not smooth and regular waves like those in the natural sciences, the regularities of the business cycle are in the co-movements (i.e. conformity as defined in Mitchell (1951) and coherency as defined in modern time series language), among the different and aggregated time series. Although nothing exists on the behavior of observed economic time series that precludes ordering them in equilibrium terms (Lucas, 1977), neither does this dissertation study propose a complete general equilibrium model to account for all the intricate and dynamic relationships among the aggregated time series. Nevertheless, this dissertation study investigates housing market dynamics holistically, based on its business cycle features and within the foregoing general equilibrium framework.

4.3 Generalized Dynamic Factor Model (GDFM)

The model adopted in this Chapter is the GDFM developed FHLR (2000; 2001; 2003; 2004; 2005); and by Forni and Lippi (2001). It is appropriate to validate the corresponding theoretical framework established in Section 4.2 owing to several features of the model. For example, its appealing representation enables transparent dynamic relationships among its variables, and it offers a consistent paradigm that can handle the most important forms of measurement error (Altonji *et al.*, 2002).

The Advantages of the GDFM

A key novelty of the dynamic factor model (DFM) is that all the required procedures are consistently nested in a unified theoretical setting in sharp contrast to conceptually disjoint operations. However, the GDFM itself improves the classical factor model by allowing the idiosyncratic components to be weakly cross-correlated at all leads and lags, neither requiring any finite restriction on the order of the dynamic loading functions. Its major advantages over standard techniques can be summarized as follows: firstly, and in comparison to the NBER method (FHLR, 1999), the GDFM need not identify the turning points and need not select the coincident variables based on some judgmental criteria before cleaning them from noise, measurement errors and other idiosyncratic disturbances. The resulting retention of the leading and lagging variables makes it possible to investigate the extra information for the estimation of the coincident indicator. Secondly, and in comparison to the traditional structure model or the simultaneous regression models, the GDFM allows us to remain "agnostic" about the structure of the economy to deal with as much information as possible (i.e. a large-scale dataset) in the time and/or cross-sectional dimensions. The GDFM can potentially accommodate data at different frequencies, of different vintages and of the different time spans (Bernanke and Boivin, 2003). A small dynamic dimension of the common component can be obtained by dynamic loading of a finite (small) number of common factors. Thirdly, and in comparison to standard low-dimension systems, the GDFM has the advantages of the statistically non-parametric approach owing to its estimation that adopts the frequency-domain based principal components analysis. The consistency of such estimation can be achieved if the number of observations is or at least of the same order as the number of time series (FHLR, 2004). Thus, the GDFM offers a clearly specified and statistically rigorous method that utilizes multiple datasets regardless of the structure of the economy. Lastly, and in comparison to similar various approaches, for example, the static (approximate) factor model or the restricted dynamic model, the GDFM is the only one that is supported by a characterization theorem, which matches the empirical evidence[23] (Hallin and Liska, 2007).

[23] A small number of empirical spectral eigenvalues diverges with $n \rightarrow \infty$.

The Model Specification

The GDFM by FHLR represents a vector of *N* time series in the sum of two mutually orthogonal components, i.e. a common component driven by a few underlying uncorrelated common shocks (factors), and an idiosyncratic component driven by variable-specific shocks. The common factors and components are inherently unobservable but can be estimated via dynamic principal components, which can take advantage of hindsight to unveil the unobservable dynamic information in the time series. Moreover, different common factors are allowed to affect the time series at different points in time, thereby permitting the GDFM to offer not only a solution to a conjectured contemporaneous interrelationship that is embedded in the observed series but together with the lagging patterns[24] permits the GDFM to exploit the dynamic covariance structure in the series[25]. Thus, the study in this Chapter adopts the GDFM and takes the full advantage of available housing market and macroeconomy information in order to systematically investigate housing market dynamics. In summary [26], the GDFM formulates a dataset that includes *N* time series as

$$x_{it} = \chi_{it} + \varepsilon_{it} = \sum_{j=1}^{q} b_{ij}(L)u_{jt} + \varepsilon_{it} \tag{4.23}$$

where, $x_{it} = (x_{1t},...,x_{nt})'; n \in N, t \in Z$ is required to be a stationary *N*-dimension vector process with zero mean. χ_{it} , ε_{it} are mutually orthogonal unobservable common and

[24] Under the GDFM, the dynamic principal components are a linear combination of past, present and future economic variables. The common component is estimated on the basis of the fitted value of an OLS regression of x_t on past and present dynamic principal components.

[25] FHLR (2003) work out the theoretical advantage of the dynamic factor model compared to the static one.

[26] Please see FHLR for more details.

idiosyncratic components of each observed variable x_{it}, respectively. $\sum_{j=1}^{q} b_{ij}(L)u_{jt}$ denotes the dynamic loading of a small number $q < N$ of common factors (shocks) to determine the common component χ_{it}. $b_{ij}(L) = B_n(L) = B_0^n + B_1^n L + ... + B_s^n L^s$, $j = 1, \ldots q$ denotes a row vector of *s*-order polynomials in the lag operator *L*. Such *s*-order dynamic loadings can differ in coefficient and lags across the variables. The coefficients B_s^n represent the impulse response function of x_{it} to the common factor (shock) u_{jt}. The vector of common factors (shocks) $u_{jt} = (u_{1t}, ..., u_{qt})'$ is a mutually orthonormal white-noise vector process at all leads and lags. Under the generalized dynamic factor structure, the idiosyncratic component ε_{it} of each variable is orthogonal to all components of the *q* common factors' vector u_{jt} at any lead and lag, thereby enabling ε_{it} to be orthogonal to the common component χ_{it} at any lead and lag. In addition, the idiosyncratic components ε_{it} are traditionally supposed to be mutually orthogonal at any lead and lag in order to ensure that each ε_{it} contains the specific information merely to x_{it}, while the GDFM permits a limited amount of correlation[27] since orthogonality is an unrealistic assumption[28] for most applications (FHLR, 2000).

Under the FHLR generalized dynamic factor framework, the estimation of the latent common factors (shocks) u_{jt} is fulfilled by estimating the dynamic principal

[27] The cross-sectional average of the correlations between the idiosyncratic components vanishes in variance as *n* tends to infinite, just as the idiosyncratic components are pair wise orthogonal. See FHLR (2005) for technical details.
[28] See examples explained in Forni and Lippi (2001).

components[29]. The main idea is summarized such that u_{jt} and the dynamic principal components are obtained through a generalization of the orthogonalization process of the variance-covariance matrix of x_{it} in the case of the static principal components[30], i.e. by the dynamic eigen values and the eigen vectors' decomposition of the spectral density matrix of x_{it}. The GDFM requires that the first q eigen values of the spectral density matrix of χ_{it} diverge, whereas the eigenvalues of ε_{it}, i.e. the last n-q eigen values of x_{nt} remain bounded. Thus, the idiosyncratic causes of dynamics, although possibly shared by different units, concentrate to affect a finite number of series and they tend to zero with N increasing to infinity. The model is asymptotically identified as $N \to \infty$ (FHLR, 2000), i.e. the poorly correlated idiosyncratic components are cancelled out by averaging along the cross-section and by shifting the series through time even while remaining all the common sources of dynamics. Hence, the dynamic principal components are increasingly collinear with the common shocks with $N \to \infty$. A brief technical explanation is provided in Appendix 4.1 for further information.

The Criterion Selection

[29] Brillinger's theory of dynamic principle components (Brillinger, 1981) serves as a main theoretical tool in the general dynamic context. The best approximation of x_{it} is the first q dynamic principle components by means of the q linear combinations of the data (Brillinger, 1981).

[30] Under dynamic principal approach, the data is shifted through time before averaging along the cross-section based on the whole set of dynamic covariances. However, static principal approach only considers the contemporaneous covariances.

To estimate the common components of each series under the GDFM (FHLR, 2000, 2001), two parameters should be selected based on appropriate criterion. One is the number of lagged covariances adopted in the Bartlett lag-window estimation of the spectral matrix. According to FHLR (2000), consistent estimates are ensured if $M(T) \to \infty$ and $M(T)/T \to 0$ as $T \to \infty$, and the rule of $M = round(\sqrt{T}/4)$ performs well. The practical sense is that a small part (the *M*-quarter lagging effect) of the dynamic information is to be considered in housing market dynamics. The other important parameter is the optimal number of common factors (shocks) q. Several criterions exist in determining this parameter in the literature. FHLR (2001) as well as Forni and Lippi (2001) propose a heuristic inspection of the eigen values against the number of variables. If the eigen values are denoted as $\lambda_{hn} = \int_{-\pi}^{\pi} \lambda_{hn}(\theta) d\theta$ based in Equation (4.23), the average of the first q eigen values over frequencies θ diverges when $h \to N$, while the average of the *(q+1)-th* eigen value over frequencies θ keeps relatively stable. Moreover, for lag n, a big gap (jump) is expected between the variance explained by the *q-th* principal component λ_{qn} and the one explained by the *(q+1)-th* principal component $\lambda_{q+1,n}$. Adding dynamic principal components is suggested until the increase in the explained variance is less than some pre-specified value. Such criterion is adopted by Favero *et al.* (2005) and by Nieuwenhuyze (2006). For the GDFM, Hallin and Liska (2007) provide a formal statistical criterion[31] based on the *(n, T)*-asymptotic characteristics of the eigen values of the sample spectral density matrices since the number q is also the number of diverging eigen values of the sample spectral density matrix as $n \to \infty$. This criterion performs

[31] See Hallin and Liska (2007) on sufficient conditions for consistency of the criterion with large n and T.

quite well even in data panels with moderate *n, T* and non-negligible idiosyncratic cross-correlation. The Hallin and Liska's method is adopted in the present research while an alternative approach is introduced in Appendix 4.2 for information.

4.4 Common Components and Commonality

Technically, the common component[32] is produced by a series of impulse response functions of the original observable variable to a few unobservable common factors. Such a few common latent factors are sources of multivariate correlation. Theoretically, "…changes or shocks to the fundamental value of housing are not transmitted solely through market prices but through market liquidity as well" (Krainer, 2001). Therefore, under the GDFM specification in this research, the common component of the housing price index would represent the common price variation across different individual houses in the same market. Such common variation in housing prices captures the state of the economy and changing housing market conditions as a whole. It is defined as the "time-series variation" of the observed house price variation by Schulz and Werwatz (2004). In a study by Nieuwenhuyze (2006), the amount of the common dynamics information held in each variable x_i can be measured by the degree of commonality C_i in Equation (4.24).

$$C_i = \frac{\text{var}(\chi_i)}{\text{var}(x_i)} \tag{4.24}$$

[32] In economics, factor model arises to explain GDP growth rate for country *i* in period *t*. The common component is the heterogeneous impacts of the common shocks multiplying the vector of the shocks. The idiosyncratic component represents the country-specific growth rate. In finance, factor model is applied to explain the return for asset *i* in period *t*. The common component equals the exposures to the factor risks multiplying the vector of factor returns, while the idiosyncratic returns are captured in the idiosyncratic component.

4.5 Data Source and Management

According to the theoretical framework in Section 4.2 and the foregoing review of the Singapore case shown in Table 2.1, as well as the data availability for Singapore case, 25 variables are identified and tabulated as shown in Table 4.1 inclusive of macroeconomic and housing market-specific variables albeit not exhaustive. The variables on a monthly or quarterly basis are included in the required data panel spanning from 1988:Q1 to 2007:Q4, containing information on the housing sector, the financial and macroeconomic conditions in Singapore. The sources for the data are also listed in Table 4.1. To investigate the key features of housing market dynamics over time, the whole sample period (1988-2007) are split into two sub-periods from 1988:Q1 to 1998:Q4 and from 1999:Q1 to 2007:Q4. The split is because the Singapore private housing market is widely deemed to be speculative during the 1990s especially around 1996 as shown in Fig 4.3(a). The variables in turn are seasonalized[33], first-differenced[34] and then normalized[35] to meet the GDFM requirements.

It is worth pointing out that although the convergence of the factor estimates requires large cross sections and large time dimensions, the dataset need not be very large to obtain reasonably precise factor estimates (Jacobs and Otter, 2008). On the cross-sectional dimension (i.e. the number of series), Bai and Ng (2002) conclude that it need not be very large. Moreover, the theoretical framework in Section 4.2 helps to carefully

[33] Adopting the addictive moving average method.
[34] To obtain stationarity, all seasonalized variables are differenced, except interest rates and the interest rate spread.
[35] To avoid overweighting of variables with large variance in estimating the spectral density matrix under the GDFM, I subtract the mean from each variable then dividing the results by the variable’s standard deviation.

assemble the required data that need not be large, and which avoids wrongly interpreting large idiosyncratic components to be the additional common factors (FHLR, 2001).

4.6 Empirical Results and Analysis

The Number of Dynamic Factors (q)

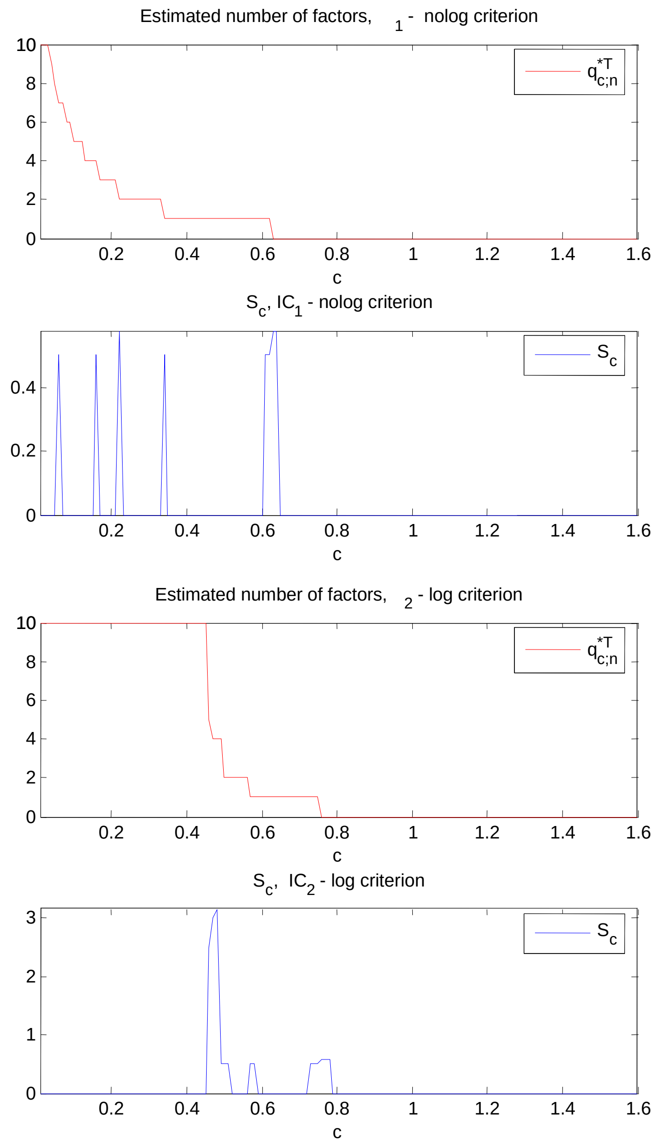
The number of common factors *(q)* for the required data panel spanning from 1988:Q1-2007:Q4 is taken to be two as shown in Fig 4.2. It means that the unobservable common housing market dynamics can be distilled from each variable in two latent common factors, and that the idiosyncratic information of each variable can be filtered out.

Macroeconomists usually propose technology, monetary or fiscal policy shocks, demand or supply shocks to be the common factors. Under the GDFM framework, extra identifying restrictions are needed and few studies try to explain the common factors[36]. In the present research, as the later findings shown in Tables 4.1 and 4.4, the top and the last rankings of the commonality ratio in the macroeconomic (time) series interchange while the rankings of the housing market-wide series keeps being consistent over different data panels with different weights for both groups of series. It is quite natural to imply think that one of the two significant latent common factors would represents the state of the economy while the other factor would arise from a housing market-specific factor[37][38].

[36] A method for the identification of the common factors is proposed by Forni, *et al.* (2008) and is applied by Lippi and Thornton (2004).

[37] Within a structural model framework, An (2007) investigates the time series dynamics of commercial mortgage credit risk and the unobservable systematic risk factors that underlies those dynamics. In his study, the commercial property cash flow are modeled as determined by two

This implication cannot be established without additional identification restrictions under the GDFM approach, however, which is beyond to scope of the current study.



NB. The figures are obtained using Liska's Matlab program; setting M=sqrt(T)*0.75 and p2

Fig 4.2 Estimating the Number of Common Factors *(q)* for the data panel, 1988:Q1–2007:Q4

unobservable factors: the macroeconomic condition and a commercial property market-specific factor.

[38] "Housing price fluctuations can be driven by macro factors and intrinsic characteristics of the housing market itself." See page 11 in Zhu (2003)

On Commonality

Table 4.1 shows the degree of commonality for the required data panels under the GDFM. With respect to the required panel spanning the whole period from 1988:Q1-2007:Q4, about 29.57% (the percent form of 0.2957) of the housing price index total variance is related to housing market dynamics. Private consumption expenditure shows the highest commonality ratio of 1.0017, which implies that the private consumption expenditure provides the most adequate view of the state of the housing market dynamics from a general equilibrium perceptive. It provides another support for the housing price-consumption channel (as investigated in Chapter 3) pertaining to the interaction between the housing market and the economy. The 12-month fixed deposit rate, saving deposit rate, prime lending rate and the 15-year housing loan rate have relatively high commonality ratios in their absolute value form of 1.0001, 0.8878, 0.8847 and 0.6290, respectively. The commonality ratio of housing price index ranks in 9th place among the total 25 variables. Averaging commonality ratio across all the series is 0.5094, which implies that on average, the common component contributes about 51% of the series' total variance.

Looking at the two sub-period data panels, the housing price index shows a relatively higher commonality ratio of 42.00 % in the more volatile period (from 1988 to 1998), and a relatively lower commonality ratio of 17.65% in the less volatile period (from 1999 to 2007), compared to the whole period (from 1988 to 2007). While in the longer run (from 1988 to 2007), approximately 29.57% of the housing prices total variance is related to housing market dynamics. Hence, such a commonality ratio varies over time; specifically it is higher in the period with more housing prices volatility. According to the commonality ratios, the housing price index ranks in 7th place in the more volatile period and ranks in 13th place in the less volatile period. Private consumption expenditure and the 12-month fixed deposit rate still keep the first two highest commonality ratios in both periods. The prime lending rate, saving deposit rate and the 15-year housing loan rate still show relatively high commonality ratios. Hence, with regard to the macroeconomic time series, the private consumption expenditure and the 12-month fixed deposit rate convey high commonality over time. The same trend is observed for the prime lending rate and the 15-year housing loan rate that constitute the housing market-wide series. Furthermore, driven by two latent common factors, the representative series with high degrees of commonality for the macroeconomic series and housing market-specific series are the ones that are highly related to financial conditions, such as the saving deposit rate, the all-share stock price index, housing loan, prime lending rate and the 15-year housing loan rate). It is evident that: the functioning of the housing market relies heavily on the housing financing system (Zhu, 2003). The stamp duty, income tax and M3 money supply series have relatively lower commonality ratios for all the three time periods. The implication is that the variations of these three series are almost unrelated to the housing market dynamics, and they are more likely to evolve from idiosyncratic government actions. On the whole, the ranks of each series' commonality are almost consistent over time. The average commonality ratio over all the series is higher (lower) during the period with more (less) volatility in housing prices.

Table 4.1 Three Data Panels and Their Degree of Commonality

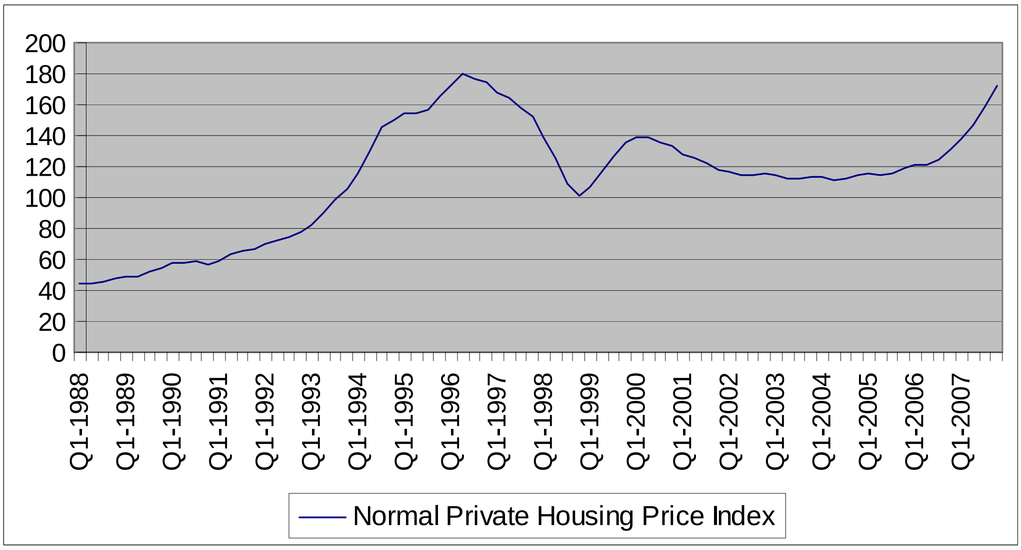
Series (N=25)	Commonality			Data Sources and Notes
	1988 Q1-2007 Q4 (T=80)	1988 Q1-1998 Q4 (T=44)	1999 Q1-2007 Q4 (T=36)	
Normal private housing price index	0.2957 (9)	0.4200 (7)	0.1765 (13)	URA; The index is computed based on fixed weights before 4th quarter 1998. The weights used to compute the index are updated every quarter from 4th quarter 1998; 4th quarter 1998 = 100
Stamp duty	0.0736 (21)	0.1363 (19)	0.0340 (24)	SDOS
Rental value index	0.1282 (14)	0.1839 (15)	0.1180 (18)	JLL
Value of contracts awarded by residential building	0.1200 (16)	0.1147 (20)	0.1639 (15)	BCA
Value of progress payments certified by residential building work	0.1247 (15)	0.2580 (12)	0.0962 (20)	BCA
Housing loan	0.1005 (17)	0.1432 (18)	0.1048 (19)	MAS; loans and advances of finance companies include lease financing and bills discounted/purchased and block discounting agreement among finance companies. OCBC finance is integrated into the banking sector in NOV 03.
Prime lending rate	0.8847 (4)	0.9137 (3)	0.8205 (4)	MAS; It is at the end of month, referring to average rates quoted by 10 leading banks.
Housing loan rate for 15 years	0.6290 (5)	0.6917 (5)	0.3363 (6)	MAS; referring to average rates compiled from that quoted by 10 leading banks.
Consumer price index of housing	0.1414 (13)	0.1645 (16)	0.1652 (14)	SDOS
Central provident fund contributions, withdrawals and amount due to approved residential property	0.0625 (22)	0.1041 (23)	0.0821 (22)	CPFB;
Formation of companies by real estate, rental &	0.0760 (20)	0.2283 (13)	0.1907 (12)	ACRA

leasing activities				
Unit labor cost overall economy	0.3441 (8)	0.2792 (11)	0.4328 (5)	SDOS
Average monthly nominal earnings per employee	0.0917 (18)	0.1533 (17)	0.0922 (21)	MOM CPFB; From 1998, the data are compiled using 5-digit fields instead of 4-digit. It is computed using data from the CPF board. It includes bonuses, if any, but excludes employers' CPF contributions. The data pertains to all full-time and part-time employees who contribute to the CPF. From 1992, the data excludes all identifiable self-employed persons.
Income tax	0.0401 (24)	0.0684 (25)	0.0778 (23)	SDOS
Unemployment rate	0.1648 (11)	0.3230 (10)	0.1301 (17)	MOM
Consumer price index of all items	0.1614 (12)	0.3610 (9)	0.1525 (16)	DOS
General business expectations	0.2602 (10)	0.2142 (14)	0.3064 (8)	EDB; Forecast for nest 6 months
Private consumption expenditure	1.0017 (1)	1.0020 (1)	1.0021 (1)	SDOS
Gross domestic product	0.3620 (6)	0.4391 (6)	0.3316 (7)	SDOS; AT 2000 market prices
M3 money supply	0.0172 (25)	0.1053 (22)	0.0333 (25)	SDOS; May 1987, money supply was inflated by about $2 billion in subscription monies to the Sembawang Maritime Limited (SML) share issue, which were financed from bank credit, discount houses ceased operation in May 1987. The M3 series has been revised to included post office savings bank's fixed deposits with MAS.
Saving deposit rate	0.8878 (3)	0.8784 (4)	0.8757 (3)	MAS; At the end of month, referring to average rates quoted by 10 leading banks.
12-month fixed deposit rate	1.0001 (2)	1.0000 (2)	1.0005 (2)	MAS; At the end of month, referring to average rates quoted by 10 leading banks.
All-share stock price index	0.3465 (7)	0.4101 (8)	0.2846 (9)	SE; Data from Jan, 1990 are computed based on the share prices of all listed Singapore companies. Prior to 1990 data are based on the share prices of all Singapore and Malaysia companies listed in the stock exchange of Singapore; 1975 = 100; Average for period.
Exchange rate with US dollar	0.0883 (19)	0.0747 (24)	0.2684 (10)	MAS; As at end of period refers to the last trading day of the month.
Spread of interest	0.0611	0.1141	0.2510	MAS; Computed as savings deposit rate

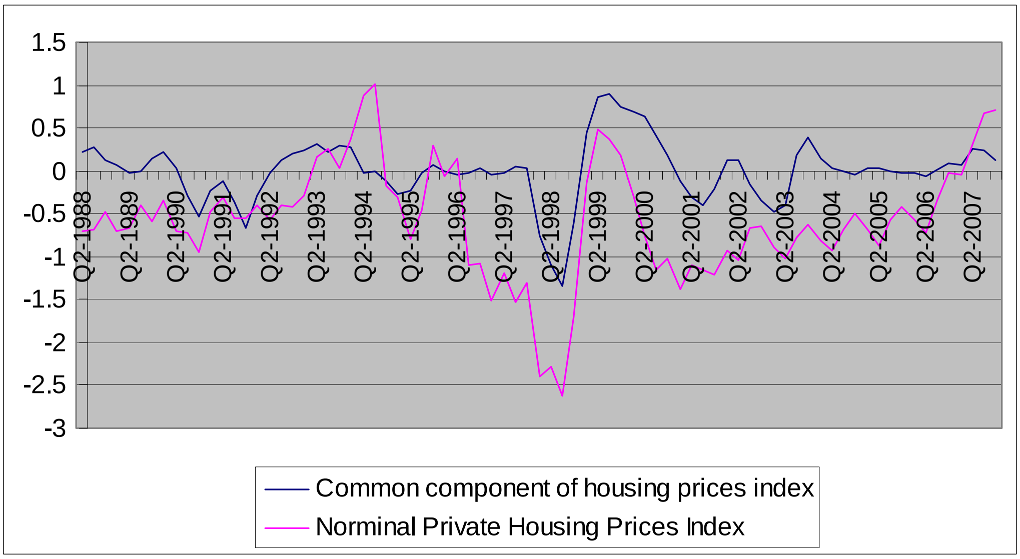
rate and 3 month-Government T-rate	(23)	(21)	(11)	minus the government securities-3-month treasury bills yield; Level instead of first-differenced.
Average over all series	0.5094	0.5352	0.5177	

NB. Numbers in parentheses are the ranks for each series' commonality ratio in each data panel.

(a) The Original Index



(b) The Normalized Index* & Its Common Component



NB. * Its treatment is a normalized, differenced & seasonalized housing price index.

Fig 4.3 The Singapore Private Housing Price Index (1988-2007)

Explanation Power of Time-Series Variation in the Housing Price Index

The explanation power of the time-series variation in housing prices with respect to the observed housing prices is provided in Table 4.2. For the whole period (from 1988 to 2007), about 37.69% (0.376968) of the variation in housing prices is explained by its time-series variation. In comparison, the explanation power is larger during the period when housing prices experience high volatility. Even during the sub-period (from 1988 to 1998) when housing prices experience relatively high boom-bust volatility, its common component at most explains approximately half (or 53.2%) of the observed housing price variation. These results validate housing market illiquidity and the non-contemporaneous adjustments[39] of housing prices in response to market dynamics. Moreover, the numerical results (from 32% to 53%) in Table 4.2 are also consistent with the results in Anas and Eum (1984). They argue that from 32 to 75% of variance in Chicago housing prices is explained by the disequilibrium housing market activity signal (for e.g., mortgage interest rate and neighborhood transaction rates of the preceding period), rather than the standard hedonic attributes under the equilibrium assumption.

Two biases in the form of an upward bias for the estimated returns and a downward bias for their risks, are primarily due to housing illiquidity that affects housing valuations that in turn guide the prices of sold houses and that implicitly assume immediate execution (Lin and Vandell, 2007). The results in Table 4.3 concerning the whole sample period

[39] When estimating the spectral matrix, the number of lagged covariances adopted in the Bartlett lag-window is set to be non zero in the estimations, i.e. different series are affected by the different lags of common shocks in a dynamic sense. Thus, the non-contemporaneous relationships in the datasets can be captured.

(from 1988 to 2007) provide evidence for such two biases in that the illiquidity-adjusted return on housing price (-0.1010) is lower than the estimated return on observed housing prices (0.0013), while the illiquidity-adjusted risk (0.5569) is higher than that for the observed housing price (0.0577). However, in the highly volatile sub-period (from 1988 to 1998), both the illiquidity-adjusted return and its risk are higher in comparison to those for the observed housing price. In the less volatile sub-period (from 1999 to 2007), both these adjusted indicators are lower in comparison to the observed housing price. The results are consistent with conventional wisdom in that during the more volatile period, housing prices that exhibit higher commonality are exposed to higher systematic risks and higher risk premiums are required. In other words, the illiquidity biases for the housing market's (or asset's) return and risk would depend on its volatility behavior during a specific period of time.

Table 4.2 OLS Regression Results of the Housing Prices Index Common Component on the Housing Price Index

Period	**1988 Q1-2007 Q4**	**1988 Q1-1998 Q4**	**1999 Q1-2007 Q4**
Coefficient of constant	-0.155264** (0.090252)	0.844857* (0.092587)	-0.528311* (0.036633)
Coefficient of common component of housing prices index	1.695215* (0.248361)	1.293598* (0.189464)	0.625844* (0.158133)
R-squared	0.376968	0.532054	0.321872
Adjusted R-squared	0.368876	0.520641	0.301323

NB. The dependent variable is obtained by normalizing the differenced log level of the seasonalized housing price index. The value in parenthesis is the standard error of each coefficient. * Denotes significance at the 0.0005 level. ** Denotes significance at the 0.05 level

Table 4.3 Testing Biases in Housing Price Returns and Risks

Indicators	Series	1988:Q-2007:Q4	1988:Q1-1998:Q4	1999:Q1-2007:Q4
Return	Original housing prices index*	0.0013	-0.1933	-2.2839
	Common component of housing prices index	-0.1010	-0.1925	-2.6950
Risk	Original housing prices index*	0.0577	0.2176	3.2896
	Common component of housing prices index	0.5569	0.5076	2.8551

* It is treated by normalizing the differenced and seasonalized housing price index; The return and risk indicators are imputed from the common formulae, $\hat{r} = \frac{\sum_{i=1}^{T} \frac{P_i - P_{i-1}}{P_{i-1}}}{T}$; $\hat{\sigma} = \sqrt{\frac{\sum_{i=1}^{T} (\frac{P_i - P_{i-1}}{P_{i-1}} - \hat{r})^2}{T-1}}$.

4.7 Robustness Checks

On robustness analyses, other three data panels are estimated taking into account two dimensions, namely, the time-dimension and the cross-series dimension that affect the weight of the macro-economic and housing market-specific type series in the data panels. The estimated number of common factors is two and consistent across all data panels[40]. Moreover, this number is robust enough in relation to the adjustable parameters in the criterions by Hallin and Liska (2007).

As shown in Table 4.4, the commonality ratio of housing prices in panel 1 (34.73%) is almost the same as that in panel 2 (34.48%) but higher than that in panel 3 (23.34%). Together with the results in Table 6.1, it can be inferred that the commonality ratio of housing price is more sensitive to the time span with different degrees of volatility compared to the series weights in the set of data panels. Again, the finding (i.e. the housing price gains a higher commonality in the period when it experiences higher

[40] The results of q selection based on Hallin and Liska's method are available for all datasets upon request.

volatility) is robust to different data panels. Such a finding can be explained by the characteristics of Singapore private housing price dynamics, i.e. their convergence and oscillations (in the 1990s) and their convergence without oscillations (in the period, 1982-2007) as concluded in Chapter 4.

In panels 1 & 2, the commonality ratios of stamp duty and the M3 money supply rank higher than those of them in other data panels while private consumption expenditure ranks lower. The implication is that some of the two common factors change in panels 1 & 2 compared to the other panels. Except for the stamp duty, M3 money supply and private consumption expenditure series, the ranking of the other series' commonality ratios only change slightly over different time spans and different data panels. The representative series with high degrees of commonality in the macroeconomic group and the housing market group still include those series that are highly related to financial conditions, for example, the saving deposit rate, the all-share stock price index, the housing loan or prime lending rate and the 15-year housing loan rate. These findings support the theory that the financial market acts as a channel between the macro-economy and housing market dynamics. On the whole, Table 4.4 clearly shows that the commonality trend is robust.

Table 4.5 suggests significant robustness of the explanation power for the time-series variation in housing prices with respect to observed housing prices as well as the earlier inference in this Chapter on the return and risk biases owing to housing marking illiquidity.

Table 4.4 Three Data Panels and Their Degree of Commonality for Robustness Tests

Series	Commonality			Data Sources
	Panel 1	Panel 2	Panel 3	
	1996 Q1-2007 Q4 (T=48; N=32)	1996 Q1-2007 Q4 (T=48; N=28)	1993 Q2-2007 Q4 (T=59; N=22)	
Private housing prices index	0.347336 (10)	0.344796 (9)	0.233357 (10)	URA
Rental index of private housing	0.400178 (7)	0.401971 (7)	0.193059 (12)	URA
Housing loan	0.9912 (2)	0.991381 (2)	0.245407 (9)	MAS
Prime lending rate	0.274436 (13)	0.265764 (13)	0.992138 (3)	MAS
Housing loan rate for 15 years	0.226896 (15)	0.220181 (15)	0.84341 (4)	MAS
All types private residential properties available	0.10412 (24)	0.103612 (22)	0.372557 (7)	URA
All types private residential properties vacant	0.172623 (18)	0.172411 (18)	0.103631 (15)	URA
landed and non-landed private housing under construction	n.a.	n.a.	0.092495 (16)	URA
Basic metals price index	0.062693 (28)	0.062851 (25)	0.052087 (19)	EDB
Stamp duty	0.414961 (5)	0.414448 (5)	0.07183 (17)	SDOS
Landed and non-landed housing supply in development pipeline	0.301084 (11)	0.299669 (11)	n.a.	URA
Provisional permission of private housing in approval construction	0.028057 (32)	0.028051 (28)	n.a.	URA
Written permission of private housing in approval construction	0.046213 (29)	0.045924 (26)	n.a.	URA
Building plan approval of private housing in approval construction	0.212088 (16)	0.211039 (16)	n.a.	URA
Building commencement of private housing in approval construction	0.163604 (20)	0.162253 (19)	n.a.	URA
Building completion of private housing in approval construction	0.076694 (27)	0.076488 (24)	n.a.	URA
Consumer price index of housing	0.170558 (19)	n.a.	n.a.	SDOS
Private consumption expenditure	0.154341 (21)	0.153422 (20)	1.001862 (2)	SDOS
Gross domestic product	0.29447 (12)	0.287028 (12)	0.376698 (6)	SDOS
Income tax	0.032334 (30)	0.032438 (27)	0.043687 (21)	SDOS
Unemployment rate	0.423828 (4)	0.416801 (4)	0.591114 (5)	MOM
Average monthly nominal earnings per employee	0.08457 (26)	0.084813 (23)	0.043742 (20)	MOM CPFB
Total trade	0.08651 (25)	n.a.	0.200105 (11)	SDOS

M3 money supply	1.02693 (1)	1.030928 (1)	0.028612 (22)	SDOS
Exchange rate with US dollar	0.138053 (23)	n.a.	0.115006 (14)	MAS
Saving deposit rate	0.380107 (8)	0.368304 (8)	1.007031 (1)	MAS
Government Securities 3-month treasury bills yield	0.248995 (14)	0.253787 (14)	0.064312 (18)	MAS
All-share stock price index	0.51405 (3)	0.506776 (3)	0.369654 (8)	SE
Consumer price index of all items	0.190743 (17)	0.192459 (17)	0.124485 (13)	DOS
Unit labor cost overall economy	0.141016 (22)	0.138277 (21)	n.a.	SDOS
Interbank overnight rate	0.405763 (6)	0.406998 (6)	n.a.	MAS
12-month fixed deposit rate	0.362005 (9)	0.349697 (10)	n.a.	MAS
Net exports of goods and services	0.030614 (31)	n.a.	n.a.	SDOS
Average over all series	0.188975	0.347247	0.178921	

NB. Panel 1 and panel 2 share the same time span; panel 1 covers more housing market-wide series, while panel 2 select representative series among the similar series group. The 28 series in Panel 2 are not completely same as those in the panel spanning from 1988-2007. Panel 3 has a different time span from panel 1 &2 and its series is more strictly selected than for panel 1 & 2. Values in the parentheses are the ranks for each series' commonality ratio in each dataset.

Table 4.5 OLS Regression Results of Three Data Panels for Robustness Tests*

Panels		1996 Q1-2007 Q4 (T=48; N=32)	1996 Q1-2007 Q4 (T=48; N=28)	1993 Q2-2007 Q4 (T=59; N=22)
Coefficient of constant		-4.467434 (0.394872)**	-4.466501 (0.396090)	-44.48941 (0.290902)
Coefficient of common component of housing prices index		1.152434 (0.197723)	1.151938 (0.199065)	0.936343 (0.162036)
R-squared		0.430176	0.426653	0.377773
Adjusted R-squared		0.417514	0.413912	0.366460
Return	**Original housing prices index*** **	4.370099	4.370099	0.825173
	Common component of housing prices index	-3.49365	-3.17547	-0.15312
Risk	**Original housing prices index*** **	6.811588	6.811588	1.770347
	Common component of housing prices index	3.715841	3.273862	0.520449

* The dependent variable is obtained through the normalized the differenced log level of the seasonalized housing prices index. ** The value in the parenthesis is the standard error of each coefficient. All the coefficients are significant at 0.0005 level. *** Its treatment, the imputation of return and risk are the same as in Table 4.3.

4.8 Summary

The literature on housing price dynamics has extensively examined the cross-sectional variation in housing prices, driven by the heterogeneity of housing under the hedonic pricing approach. This Chapter fills the current void and robustly investigates the housing market dynamics driven by the unobservable common factors and the time-series variation in housing prices. Such investigation captures the state of the economy and changing housing market conditions on the whole.

First, this Chapter establishes an economic interpretation of housing market dynamics based on general equilibrium theory. Through an equilibrium model augmented from the work of Raberto *et al.* (2006), housing is viewed as an asset and its relationships with other sectors are simply illustrated. However, the special housing asset feature and the resulting housing market illiquidity lead the ideal equilibrium state to the realistic disequilibrium state in housing market. The adjustment between the equilibrium and disequilibrium is continuous. Such continuous interactional adjustments among the sectors lead to housing market dynamics. Then, a general housing market dynamics framework is summarized according to the foregoing analysis and the relevant literature. Moreover, the business cycle feature of housing has certain technical requirements for estimating market dynamics.

The appropriate research design revolves on the GDFM specification of FHLR. Compared to the traditional structure model or the simultaneous regression model, the GDFM permits to remain “agnostic” about the structure of the economy and to take full advantage of information. Such a methodological framework also possesses statistical non-parametric advantages since the frequency-domain based principal components analysis is adopted when estimating the GDFM in this research.

The empirical analysis is conducted within the context of the Singapore private housing market. A quarterly time-series data panel in the period from 1988:Q1-2007:Q4 is adequately available to contain housing market-wide series and macroeconomic series (including financial series), on the basis of the TFA in Section 4.2. It helps to propose an *ad hoc* functional form of the GDFM in estimating housing market dynamics. Meanwhile, to investigate the features of housing market dynamics over time, the whole sample period are separated into two panels spanning the periods from 1988:Q1-1998:Q4 and from 1999:Q1-2007:Q4 owing to the high boom-bust volatility of housing prices during the 1990s in Singapore.

Applying the criterion method of Hallin and Liska (2007), the results clearly show that two latent common factors (shocks) drive Singapore's private housing market dynamics. In addition, two common factors are envisaged with one representing the state of the economy and with the other representing a housing market-specific factor. Each time series then filters out the unimportant idiosyncratic noise in order to obtain the common component that conveys information on the housing market dynamics. The representative series with high degrees of commonality for the macroeconomic series and housing market series are the ones that are highly related to financial conditions, for example, the saving deposit rate, the all-share stock price index, housing loan, prime lending rate and the 15-year housing loan rate. Such time series are highly correlated with housing market dynamics in the aggregate, which is consistent with the "monetary transmission mechanisms" demonstrated by Mishkin (2007) that monetary policy affects the housing market, and in turn the overall economy, no matter directly or indirectly through at least six channels[41]. However, the stamp duty, income tax and M3 money supply series have relatively lower commonality ratios for all the three time periods. The implication is that the variations of these three series are almost unrelated to the housing market dynamics, and they are more likely to evolve from idiosyncratic government actions. As expected, the average commonality ratio across all series is higher (lower) in the period when housing prices experience more (less) volatility.

With regard to housing price index, in the longer term (1988-2007), approximately 29.57% of the total variance in observed housing prices is related to housing market dynamics driven by two underlying common factors. Such commonality varies over time, specifically it is higher in the period when housing prices are more volatile. According to the commonality ratios, the housing price index ranks in 7th place in the more volatile period and ranks in 13th place in the less volatile period, while in 9th place during the total period. In addition, empirical estimates show that the time-series variation in housing prices only explains about 38% of the variation in the observed prices in the period 1988-2007 or at most about 53% during the shorter and highly volatile period 1988-1998, which keeps consistent with the results in Anas and Eum (1984) and confirms the housing market illiquidity feature and the non-contemporaneous adjustments of

[41] See page 5 in Mishkin (2007), six basic channels are listed as: through the direct effects of interest rates on (1) the user cost of capital, (2) expectations of future house-price movements, and (3) housing supply; and indirectly through (4) standard wealth effects from house prices, (5) balance sheet, credit-channel effects on consumer spending, and (6) balance sheet, credit-channel effects on housing demand.

housing prices in responding to the market dynamics. Furthermore, the return and risk biases of the housing asset are tested and they are found to depend on their volatility characteristics during a certain period. In Singapore case, the return is upward biased while the risk is downward biased during the 1988-2007 period, both being downward during the 1988-1998 period but both being upward during the 1999-2007 period.

CHAPTER 5 HOUSING PRICE DYNAMICS WITHIN A BEHAVIORAL CONTEXT

5.1 Introduction

The evidence on the temporary deviation of accrual prices from economic fundamentals (for e.g., Clayton, 1996) and the positive autocorrelation of housing price in the short run (for e.g., Capozza and Seguin, 1996), have merely supported the explanation of investors' irrational expectations and investor psychology. Although both explanations have been repeatedly documented in prior empirical studies (see Case and Shiller, 1989, 1990; Poterba, 1991; Cutler *et al.*, 1991; Abraham and Hendershott, 1996; Malpezzi, 1999 and Meen, 2002), there has been no systematic theory explaining housing price dynamics[42] within a behavioral context.

Rooted in behavioral finance, this Chapter establishes a disposition-momentum behavioral TFA in Section 5.2 and designs the research by modeling the behavior of disposition- and momentum-prone investors in the housing market in section 5.3. Such a behavioral model not only generates the serial correlation and the mean-reversion parameter-estimates of housing price dynamics, but also stipulates the role of different investors' behavior in determining the estimated parameters. Based on the model, four propositions are demonstrated in Section 5.3 while explaining the stylized facts (autocorrelation and mean-reversion) of housing price dynamics under the disposition-

[42] To my knowledge, only Glaeser and Gyourko (2006) mathematically have deduced the form of the serial correlation and mean reversion for housing price dynamics, and have investigated the reasons of such features. Their model fails to explain high frequency positive serial correlation and did not fully explain both of the features in the most volatile markets.

momentum theory, and identifying the characteristics of housing dynamics with reference to the definitions by Capozza (2004). Composite impacts from the different (disposition and momentum) sensitivity coefficients on the amplitude and frequency of housing price dynamics are analyzed while discussing the amplitude changes. The corresponding empirical study is carried out for the Singapore private housing market. The methodology for the model estimation and the data are introduced in Section 5.4 and Section 5.5 respectively. Section 5.6 presents the empirical results and analysis. In Section 5.7, six cases of different specifications are tested and analyzed for the robust checks. Lastly, this Chapter's findings are concluded in Section 5.8.

5.2 Theoretical Work

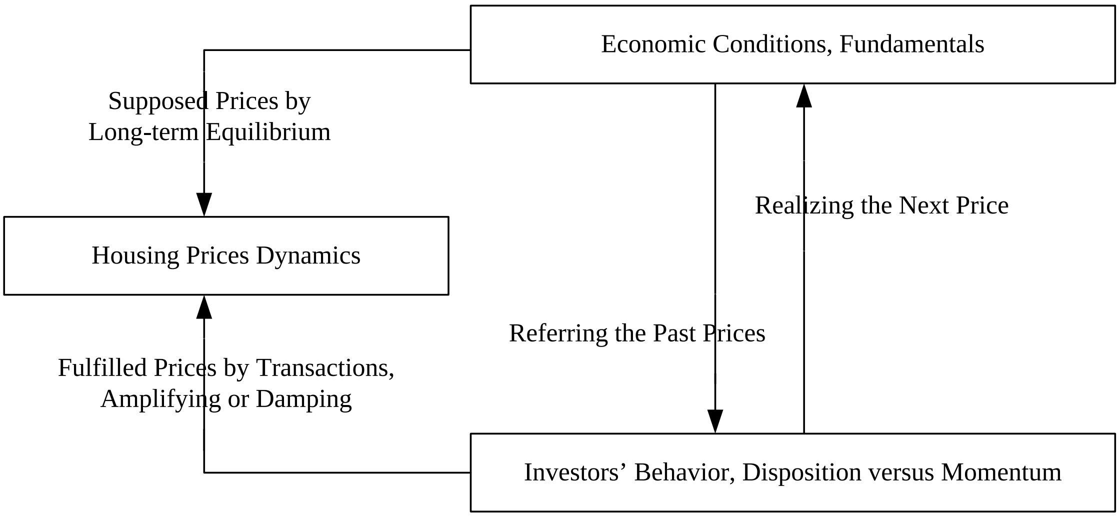
The housing market is long suspected to be inefficient[43] (Case and Shiller, 1989, 1990; Tirtiroglu, 1992; Meese and Wallace, 1994). It is observed that "The apparent predictability in housing prices, at least in the short run, leaves open the possibility of speculative purchases in the housing market" (Riddel, 1999, page 272). In addition, "Past researchers have shown that a mix of fundamental and feedback traders in a market may lead to price volatility over and above that driven by rational price forecasts" (Riddel, 1999, page 273). Thus, housing price dynamics can be determined by investors' behavior and economic conditions. In recent years, practitioners and academic scholars indicate that individual investors suffer from behavioral biases like insufficient (naive) diversification, excessive trading, and some relatively simple trading strategies as reviewed by Barberis and Thaler (2002). Researchers divide these strategies into two major categories, namely the disposition strategy that relies on price reversals, and the

[43] Cho (1996) extensively surveys the literature on housing market inefficiency.

momentum strategy that is based on price continuation (Shen, *et al*., 2005). Among the behavioral biases, the disposition effect has gained most attention. Although many studies utilize financial assets, the disposition effect has also been documented for the Finnish apartment market (Einio and Puttonen 2006), or individuals' behavior in the sale of housing (Genesove and Mayer, 2001), and even for professional investors at an Israeli brokerage house (Shapira and Venezia, 2001). In Genesove and Mayer (2001), sellers with nominal losses tend to require higher asking prices and they have a lower hazard rate of selling. However, conditional upon selling, they would receive higher prices, thereby providing micro-evidence that the higher and different pricing levels do relate housing equity accumulation prior to the sale but during a brief spell, may lower the marginal probability to sell a unit, while the impact on the downside is stronger. Thus, in terms of housing market, the investors' disposition effect should be deemed to affect their realized housing prices.

Intuitively, if only one kind of investors, the disposition investors, exist in the private housing market, at any specific point of time, then all investors would behave as sellers or potential sellers. In reality, housing transaction prices only require that "price and volume are simultaneously determined in equilibrium. Whatever process that generates price also gives rise to the accompanying trading volume" (Lee and Swaminathan, 2000, page 2065). Moreover, "past trading volume also predicts both the magnitude and persistence of price momentum" (Lee and Swaminathan, 2000, page 2017). Thus, there must be some kind of investors with a contrarian behavior that is akin to disposition investors in the market. The literature recommends the momentum strategy as that contrarian behavior (e.g., Shen *et al*., 2005). According to Strobl (2003), disposition effects are consistent with price momentum. Massa and Goetzmann (2000) offer the evidence that trades between the disposition-prone investors and their counter-parties (the momentum investors), impacts relative prices. It is therefore reasonable to characterize housing price dynamics by taking into account both types of investor behavior within the disposition and momentum theory.

Consequently, the TFA from the behavioral perspective considers only investors that prevail in the housing market and that they are heterogeneous. The underlying reasons are that the nature of the housing market has been realized to be a typical asset market in the behavioral finance discipline, owing to the dual roles of housing real estate. So, in this topic, we consider both its investment factors and consumption factors while housing consumption is assumed to be unchanged in the short run. It implies that investors, even speculators, play the most important role in the housing market. Such an assumption is supported in the literature, i.e. the disposition behavior or disposition effect has been observed and documented in the housing market, based on empirical studies (see Genesove and Mayer, 2001). No government intervention is expediently assumed. It is reiterated that "Housing markets are inefficient and house prices, at times, deviate from fundamental or intrinsic values. A sharp run-up in housing price is partly due to irrational expectations (fads, noise traders, trend chasing) and signals a future correction, as housing prices are ultimately anchored by (cointegrated with) market fundamentals" (Clayton, 1997, page 359-360). Since investor expectations are not rational, they are not homogeneous. Thus, it can be envisaged that there are two kinds of investors in the housing market. Fig 5.1 depicts the framework for the theoretical model that is mathematically developed later in Section 5.3.

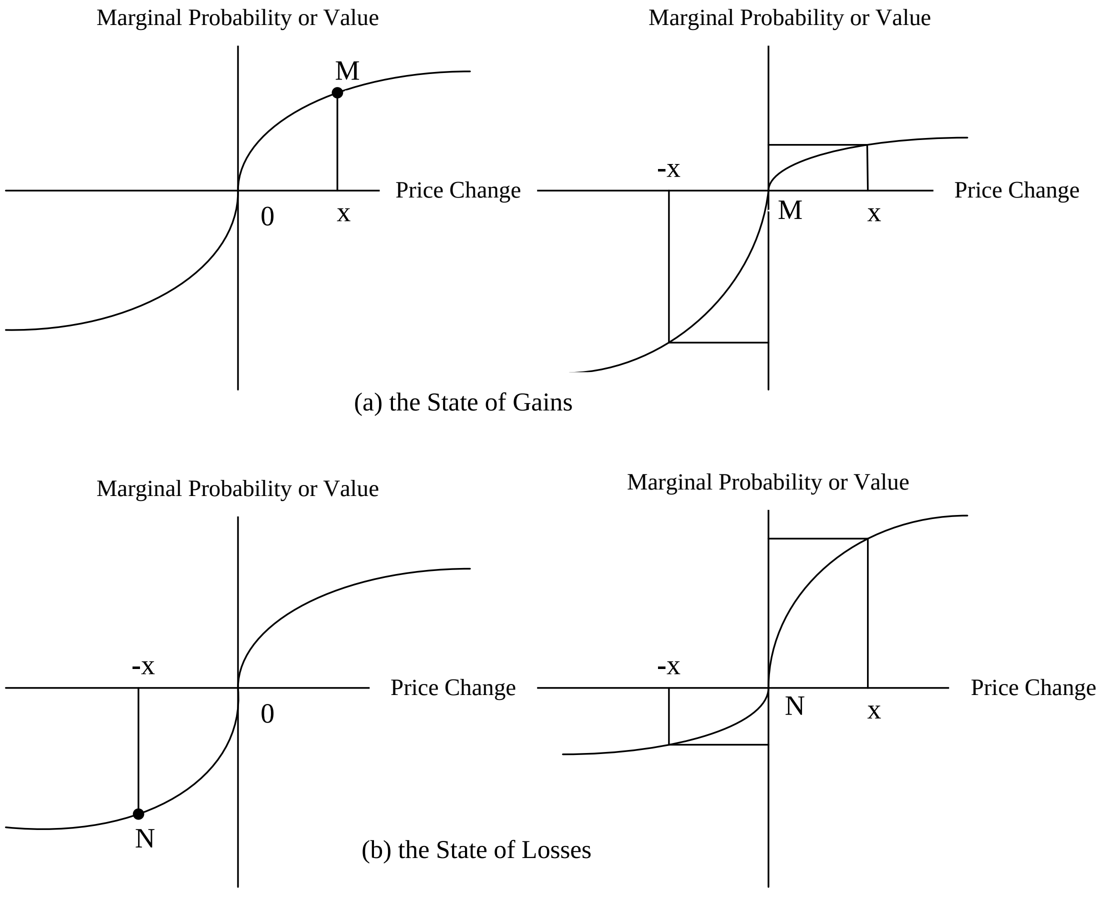


(***Source***: Author, 2009)

Fig 5.1 Outline of the Theoretical Model from Behavioral Perspective

There are two types of investors in Fig 5.1. One kind is the disposition-prone investors, who seek risk when faced with possible losses and who avoid risk when a certain gain is possible (Kahneman and Tversky, 1979). Such behavior is equivalent to a utility function, which is steeper for losses than for gains (Tversky and Kahneman, 1992) unless it is defined on gains and losses instead of on levels of wealth (Odean, 1998). The nature of the disposition behavior proposes an asymmetric S-shaped value function. This function is a departure from the standard expected utility maximization framework in that an S-shaped value function for investors is centered around a profit of zero on a given trading position. According to prospect theory (Kahneman and Tversky, 1979), the disposition-prone investors have already experienced gains or losses. Their initial state is not zero when they make decisions to hold or sell their housing units. A motivated seller's marginal probability to sell the unit is assumed to be the carrier of loss aversion (Genesove and Mayer, 2001; Engelhardt, 2003).

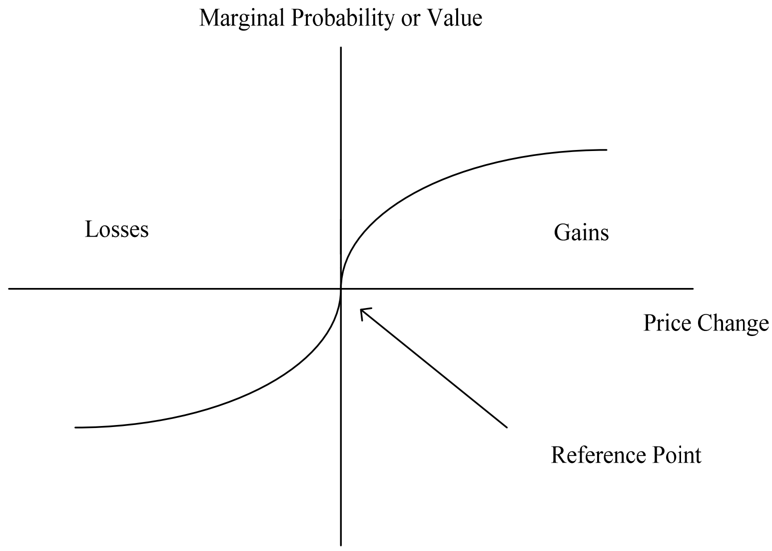
Fig 5.2 depicts the behavior of the disposition-prone investors' value functions. Fig 5.2(a) displays the state of gains: from a gain point M, to increase x revenue that brings less happiness to the investors than the sorrow caused by an increasing x deficit. Fig 5.2(b) displays the state of losses: from a loss point N to increase the x deficit that brings less sorrow to the investors than the happiness caused by an increasing x revenue.



(*Source*: Tao, 2007 (unpublished); Author, 2008)

Fig 5.2 Value Function of Disposition-Prone Investors in Gains and Losses Condition

The other kind investor in Fig 5.1 denote the momentum-prone investors, who expect the continuation of the housing market; to behave well in the next moment when the market is currently in good condition, or to behave badly in future when the market is currently in bad condition. The value function of momentum-prone investors is concave in the domain of capital gains, and it is convex in the domain of capital losses as depicted in Fig 5.3. However, it is different from the one for disposition-prone investors: zero becomes the reference point for the strategies of the momentum-prone investors while both initial states of gains and losses are zero.



(***Source***: Tu *et al.*, 2007; Author, 2008)

Fig 5.3 Value Function of Momentum-prone Investors in Gains and Losses Condition

5.3 Model Construction

The behavior of disposition-prone investors is that they sell the housing unit when housing price increases. However, the price changes do not definitely lead the disposition effect since disposition-prone investors refer to a price when making decisions. Such price acts as a benchmark price. In this paper, the fundamental price is selected to be the reference point. The disposition-prone investor then gains the characteristics of the "fundamental investor", as defined in the study by Riddel (1999), "…who bases price forecasts on expected economic conditions in the area. This type of investor would be more likely to purchase a home when prices are low is relative to expected fundamentals and to sell when the converse is true". In the short run, it is supposed to be the linear relationship between the changes of disposition-prone investors' demand and housing prices, expressed in Equation (5.1)[44]:

$$D_t^D = -\alpha(P_t - P^*); \alpha > 0 \tag{5.1}$$

, where, D_t^D is the change of the disposition-prone investors' demand in period t; P_t is the housing price in period t; P^* is the reference price in the log of the equilibrium value per unit, $P^* = P_t^* = p(X_t)$, X_t is a vector of exogenous explanatory variables as proxy of economic condition; α indicates the sensitivity of disposition-prone investors to housing price changes.

With regard to momentum-prone investors, the changes of their demand depend on housing price changes in every term of equation (5.2). The momentum effect appears when the housing price changes shows inertia by increasing or decreasing continuously. In this paper, it is assumed for at least two periods, i.e. this period and the last period. The linear function is

[44] An incunabular work of modeling demand functions of both disposition-prone investors and momentum-prone investors can be found in Tao Guan's unpublished paper.

$$D_t^M = \beta_1(P_t - P_{t-1}) + \beta_2(P_{t-1} - P_{t-2}); \beta_1, \beta_2 > 0 \quad (5.2)$$

, where D_t^M is the change of momentum-prone investors' demand in period t; P_t, P_{t-1} and P_{t-2} are housing price in period t, t-1 and t-2, respectively; β_1 and β_2 indicate the sensitivities of momentum-prone investors to different periods' price changes. The relative magnitude between β_1 and β_2 need not be defined. The reason is that although sensitivity is diminishing, i.e. the marginal value of both the gains and losses decreases with increasing changes of housing prices as shown in Fig 3.4, $P_t - P_{t-1}$ and $P_{t-1} - P_{t-2}$ are just required to keep up its inertia (with the same sign), rather than to be larger or smaller (comparing their absolute values).

In the literature, this study is a first one carried out in behavioral finance theory to explain housing price dynamics, and the literature is lacking in studies to quantify the characteristics of housing, owing to its the dual roles. We therefore take the extreme assumption that the housing supply has perfect elasticity without transaction friction as an ideal condition[45]. The resulting state of the housing market can be expressed as the sum of all demand changes of the disposition-prone investors and the momentum-prone investors plus the supply of new units in period *t*:

$$D_t^D + D_t^M + N = 0 \quad (5.3)$$

, where N are some units from the new supply in the market at time *t*. Using Equation (5.1) and Equation (5.2) to substitute D_t^D and D_t^M in Equation (5.3) produces

[45] Under such an assumption, the investigation focuses on an ideal case to explore housing price dynamics within the behavioral finance framework. Relaxing this assumption would call for future studies.

$$\beta_1(P_t - P_{t-1}) + \beta_2(P_{t-1} - P_{t-2}) - \alpha(P_t - P^*) + N = 0 \tag{5.4}$$

Equation (5.4) can be rewritten as,

$$P_t + \frac{\beta_2 - \beta_1}{\beta_1 - \alpha} P_{t-1} - \frac{\beta_2}{\beta_1 - \alpha} P_{t-2} + \frac{N + \alpha P^*}{\beta_1 - \alpha} = 0 \tag{5.5}$$

Equation (5.5) is a second-order difference equation and its solution includes a particular integral and complementary functions. Let $P_t = P_{t-1} = P_{t-2} = l$, where l is a constant, then the particular integral of Equation (5.5) is obtained as[46]

$$C = \frac{\dfrac{\alpha P_0 + N}{\alpha - \beta_1}}{1 + \dfrac{\beta_2 - \beta_1}{\beta_1 - \alpha} - \dfrac{\beta_2}{\beta_1 - \alpha}} = P^* + \frac{N}{\alpha} \tag{5.6}$$

A difference equation with convergent variable tends to arrive at the particular integral finally. As mentioned, P^* is a benchmark price for the disposition-prone investors' behavior when they take into account economic conditions to make decisions. Equation (5.6) therefore shows the benchmark price of disposition-prone investors, i.e. the economic conditions, the sensitivity of disposition-prone investors to housing price changes and some of the new supply, are to be the determinants of the final state of the housing market. The complementary functions of Equation (5.5) are obtained by applying the "Z-transform" $\lambda^n = P_n$, a quadratic equation for the unknown λ is

$$\lambda^2 + \frac{\beta_2 - \beta_1}{\beta_1 - \alpha}\lambda - \frac{\beta_2}{\beta_1 - \alpha} = 0 \tag{5.7}$$

Equation (5.7) is the characteristic equation from which the characteristic values (roots) can be obtained

[46] The explanation on the solution of the second-order difference equations can be found in most mathematical textbooks, for example, that by Logan (2006), Polking (2001) or Ricardo (2003).

$$\lambda_1 = \frac{1}{2}\left(\frac{\beta_1 - \beta_2}{\beta_1 - \alpha} + \sqrt{\frac{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}{(\beta_1 - \alpha)^2}}\right) \quad (5.8a)$$

$$\lambda_2 = \frac{1}{2}\left(\frac{\beta_1 - \beta_2}{\beta_1 - \alpha} - \sqrt{\frac{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}{(\beta_1 - \alpha)^2}}\right) \quad (5.8b)$$

When $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 > 0$, there are two real unequal characteristic roots λ_1, λ_2, hence, the solution to the difference Equation (5.5) contains a linear combination of these two values in the form,

$$P_t = A_1 e^{\lambda_1 t} + A_2 e^{\lambda_2 t} + C \quad (5.9)$$

A_1, A_2, C are constant. When $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 = 0$, there is repeated real roots $\lambda = \frac{1}{2}(\frac{\beta_1 - \beta_2}{\beta_1 - \alpha})$, then, the general solution to Equation (5.5) is

$$P_t = A_3 e^{\lambda t} + A_4 t e^{\lambda t} + C \quad (5.10)$$

When $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 < 0$, the roots of the characteristic equation are complex conjugates in the expression,

$$P_t = e^{\frac{1}{2}(\frac{\beta_1 - \beta_2}{\beta_1 - \alpha})\cdot t}\left(A_5 \cos\left(\sqrt{\frac{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}{4(\beta_1 - \alpha)^2}} \cdot t\right) + A_6 \sin\left(\sqrt{\frac{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}{4(\beta_1 - \alpha)^2}} \cdot t\right) + C \quad (5.11)$$

Or $$P_t = e^{\frac{1}{2}(\frac{\beta_1 - \beta_2}{\beta_1 - \alpha})\cdot t} A \cos\left(\sqrt{\frac{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}{4(\beta_1 - \alpha)^2}} \cdot t - \varphi\right) + C \quad (5.12)$$

Equation (5.12) is the phase-amplitude form of the general solution. amplitude $A = \sqrt{A_5^2 + A_6^2}$; phase $\varphi = \arctan\frac{A_6}{A_5}$. All $A_i, i = 1,...6$, C and φ are constants that depend on the initial conditions. The specific solutions are provided in Appendix 5.1 while the constructed model implications are next discussed in terms of two key propositions below.

From the above analysis on the roots of the second-order difference equation, it is implicit that four main propositions can be formulated and accordingly examined.

Proposition 1. The interaction of the disposition-prone and momentum-prone investors results in the time path of housing prices featured in the autocorrelation and mean reversion. The autocorrelation and mean reversion parameters are expressed by composite coefficients: the proportion of the momentum coefficient to the last period price changes in the sum effect from disposition behavior and momentum behavior to this period price changes; and the proportion of the disposition coefficient to this period price changes in the sum effect from the disposition behavior and momentum behavior to this period price changes, respectively.

Specifically, with the autocorrelation parameter $\tilde{\alpha} = \dfrac{\beta_2}{\alpha - \beta_1}$ and the mean reversion parameter $\tilde{\beta} = \dfrac{\alpha}{\alpha - \beta_1}$, Equation (5.5) is rewritten in Equation (5.13),

$$P_t - (1 + \tilde{\alpha} - \tilde{\beta})P_{t-1} + \tilde{\alpha}P_{t-2} - \tilde{\beta}P^* - \tilde{\gamma}P^* = 0 \tag{5.13}$$

, where, $\tilde{\gamma} = \dfrac{N}{\alpha - \beta_1}$.

Substituting $P_t - P_{t-1}$ and $P_{t-1} - P_{t-2}$ in Equation (5.13) with ΔP_t and ΔP_{t-1}, respectively, the characteristics of the time path of the housing price dynamics are represented in Equation (5.14),

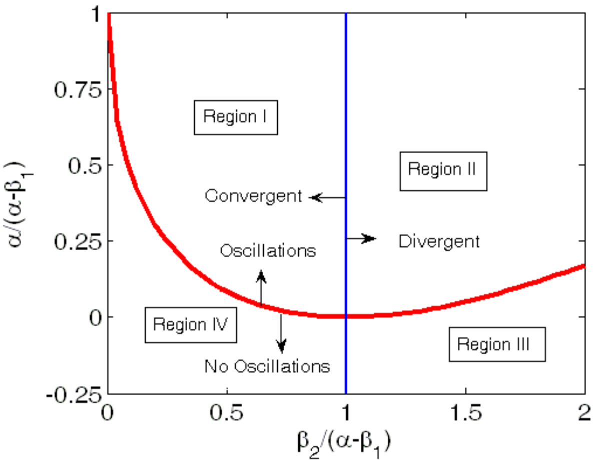
$$\Delta P_t = \tilde{\alpha}\Delta P_{t-1} + \tilde{\beta}(P^*_{t-1} - P_{t-1}) + (\tilde{\beta} + \tilde{\gamma})\Delta P^*_t \tag{5.14}$$

Equation (5.14) reinterprets the key stylized facts of the housing market: positive serial correlation of price changes at one year frequencies (Glaeser and Gyourko, 2006), and a long-run tendency for "fundamental reversion" with prices responding to contemporaneous economic shocks (Lamont and Stein, 1999). Distinctively, grounded on the disposition and momentum theory, Equation (5.14) can be duly explained. The autocorrelation parameter is determined by the proportion of the momentum coefficient β_2 to the last period price changes ΔP_{t-1} in the sum effect ($\alpha - \beta_1$) from the disposition behavior and the momentum behavior to this period price changes ΔP_t, i.e. $\tilde{\alpha} = \frac{\beta_2}{\alpha - \beta_1}$. It is the momentum effect that mainly contributes to continuous price change and hence it serves as a numerator in defining the autocorrelation. Keeping similar logic as to the serial correlation, the mean reversion parameter is determined by the proportion of the disposition coefficient α to this period price changes ΔP_t in the sum effect ($\alpha - \beta_1$) from the disposition behavior and the momentum behavior to this period price changes ΔP_t, i.e. $\tilde{\beta} = \frac{\alpha}{\alpha - \beta_1}$. It is the disposition effect that mainly leads housing price changes in a reversion manner and hence it serves as a numerator in defining the mean reversion. Both composite parameters imply that the interaction between the two kinds of investors affects the autocorrelation and mean-reversion. This specific deduction is provided in Appendix 5.3.

Proposition 2. The characteristics of the housing price dynamics can be anatomized into four types but based on two critical conditions: whether oscillations (cycles) or not and *to be determined by* $(\beta_1+\beta_2)^2-4\alpha\beta_2=0$ *or* $(1+\tilde{\alpha}-\tilde{\beta})^2-4\tilde{\alpha}=0$*; whether convergent to the long-run equilibrium or not and to be determined by* $\beta_2=\alpha-\beta_1$ *or* $\tilde{\alpha}=1$.

Mathematically, a necessary condition for the housing price dynamics in oscillations (cycles) is that the complex roots occur: $(\beta_1+\beta_2)^2-4\alpha\beta_2<0$ or $(1+\tilde{\alpha}-\tilde{\beta})^2-4\tilde{\alpha}<0$. With restrictions from the economics of the propositional problem, the absolute value of the serial correlation $\tilde{\alpha}$ being less than one serves as a necessary condition for convergence to equilibrium[47] (Capozza *et al.*, 2004; Capozza and Israelsen, 2007). Subsequently, housing price dynamics can be categorized into four types but under the two foregoing conditions. In this paper, the autocorrelation parameter $\tilde{\alpha}$ and the mean reversion parameter $\tilde{\beta}$ are composite parameters derived from α,β_1,β_2, which are sensitivity coefficients of the disposition and momentum-prone investors. Hence, the space of composite parameters with coefficients α,β_1,β_2 can be graphically divided into four regions as shown in Fig 5.4. The different combination of both parameter values generates different dynamic patterns when equilibrium is “shocked”. Therefore, our difference model proclaims that the interaction between both types of investors is a crucial force of housing price dynamics, and it also determines the properties of such dynamics.

[47] See appendix A in Capozza *et al*. (2004) for more details.



(***Source***: Capozza *et al.*, 2004; Author, 2008)

Fig 5.4 Housing Price Dynamic Features From the Difference Equation

Specifically, $(\beta_1+\beta_2)^2-4\alpha\beta_2=0$, i.e. $\alpha=\frac{(\beta_1+\beta_2)^2}{4\beta_2}$ acts as a critical condition for oscillations or not: if $\alpha>\frac{(\beta_1+\beta_2)^2}{4\beta_2}$, then oscillatory behavior (overshooting); if $\alpha<\frac{(\beta_1+\beta_2)^2}{4\beta_2}$, then a damped behavior (no overshooting). $\tilde{\alpha}=\frac{\beta_2}{\alpha-\beta_1}=1$, i.e. $\alpha=\beta_1+\beta_2$ is a critical condition for convergence or not: if $\alpha>\beta_1+\beta_2$, then a convergent behavior; if $\alpha<\beta_1+\beta_2$, then a divergent behavior. With regard to each region, the following cases provide the useful insights:

Case (1). When $\alpha<\beta_1$, which ensures $\alpha<\frac{(\beta_1+\beta_2)^2}{4\beta_2}$, i.e. $(1+\tilde{\alpha}-\tilde{\beta})^2-4\tilde{\alpha}>0$, it means that the dynamics shows no oscillations. When $\alpha<\beta_1$, it also ensures $\alpha<\beta_1+\beta_2$, which suggests that the dynamics is divergent. Such kind of dynamics lies in Region III (no oscillations-divergence dynamics). The theoretical explanations are that when the disposition-prone investors' sensitivity to the price change is smaller than the composite sensitivity of the momentum-prone investors, i.e. $\alpha < \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$, then the strengthen of the oscillation fluctuation contributed by disposition-prone investors is not enough to overwhelm the one of continuous rise or decline by momentum-prone investors. The total sensitivity to price change of the disposition-prone investors is smaller than the one of the momentum-prone investors, i.e. $\alpha < \beta_1 + \beta_2$, and it means that if the price rises then the demand of the disposition-prone investors (selling) is not enough to satisfy the demand of the momentum-prone investors (buying). The housing price and so would the price decline. Hence, it leads to price divergence.

<u>Case (2) a</u>. When $\alpha > \beta_1$, and $\alpha < \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$, i.e. $(1 + \tilde{\alpha} - \tilde{\beta})^2 - 4\tilde{\alpha} > 0$, it can be rewritten as $\beta_1 < \alpha < \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$.

If $\beta_1 < \beta_1 + \beta_2 < \alpha < \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$, then it is in Region IV (no oscillations-convergence dynamics). The theoretical explanations are that when the total sensitivity to price change of the disposition-prone investors is larger than the one of the momentum-prone investors, then the resistance to housing price emerges from the disposition-prone investors' sufficiently to counteract the impetus to the housing price from the momentum-prone investors. So, it leads to price convergence.

If $\beta_1 < \alpha < \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$ and $\alpha < \beta_1 + \beta_2$, then, it suggests Region III (no oscillations-divergence dynamics). The theoretical reasons are the same as in Case (1).

Case (2) b. When $\alpha > \beta_1$, and $\alpha > \frac{(\beta_1+\beta_2)^2}{4\beta_2}$, i.e. $(1+\tilde{\alpha}-\tilde{\beta})^2 - 4\tilde{\alpha} < 0$,

if $\frac{(\beta_1+\beta_2)^2}{4\beta_2} < \alpha < \beta_1 + \beta_2$, then it suggests Region II (oscillations-divergence dynamics);

if $\alpha > \frac{(\beta_1+\beta_2)^2}{4\beta_2}$ and $\alpha > \beta_1 + \beta_2$, then it suggests Region I (oscillations-convergence dynamics). The same logic as above can provide the corresponding explanation.

Proposition 3. On housing price dynamics in oscillations, the amplitude increases sharply and concussively with the increase of $\frac{\beta_2}{\alpha-\beta_1}$ *or the autocorrelation parameter but ambiguous in* $\frac{\alpha}{\alpha-\beta_1}$ *or the mean reversion parameter; the frequency decreases steeply with the increase of* $\frac{\beta_2}{\alpha-\beta_1}$ *or the autocorrelation parameter but also ambiguous in* $\frac{\alpha}{\alpha-\beta_1}$ *or the mean reversion parameter.*

As for the oscillations, the amplitude and frequency[48] are expressed as:

$$\text{Amplitude} = \left|P_0 - P^*\right| \cdot \sqrt{\frac{4\alpha\beta_2}{4\alpha\beta_2 - (\beta_1+\beta_2)^2}} \cdot \left(\sqrt{\frac{\beta_2}{\alpha-\beta_1}}\right)^t \quad (5.15a)$$

$$= \left|P_0 - P^*\right| \cdot \sqrt{\frac{4\tilde{\alpha}\tilde{\beta}}{4\tilde{\alpha}\tilde{\beta} - (\tilde{\alpha}+\tilde{\beta}-1)^2}} \cdot \left(\sqrt{\tilde{\alpha}}\right)^t$$

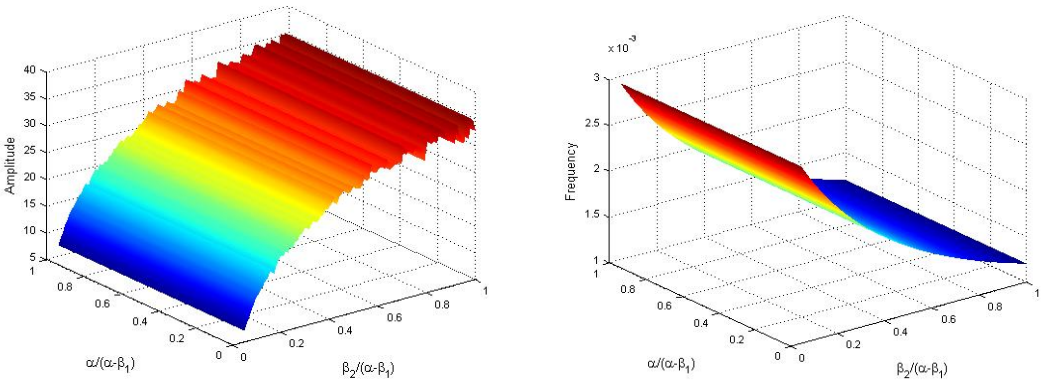
(5.15b)

[48] See Appendix 5.2 for details.

$$\text{Frequency} = \frac{1}{2\pi} \cdot \arccos\left[\frac{\beta_2 - \beta_1}{2\sqrt{\beta_2(\alpha - \beta_1)}}\right] = \frac{1}{2\pi} \cdot \arccos(\frac{\tilde{\alpha} - \tilde{\beta} + 1}{2\sqrt{\tilde{\alpha}}})$$

(5.16)

Equation (5.15a) defines that the amplitude of oscillations depends on the distance of the system at the initial point from equilibrium and on the sensitivity coefficients of both the disposition and momentum-prone investors. In Equation (5.16), the frequency is determined by the sensitivity coefficients of both investors. According to Equation (5.15b) and Equation (5.16), the relationships connecting frequency and amplitude with the two composite parameters, $\tilde{\alpha}, \tilde{\beta}$, are graphed in Fig 5.5.



(***Source***: Author, 2008)

Fig 5.5 Amplitude and Frequency of the Oscillations with the Composite Parameters

The graphs clearly depict proposition 3. Intuitively, the explanations are that if the momentum coefficient β_2 to the last period price changes is a large proportion of the sum effect ($\alpha - \beta_1$) from the disposition behavior and the momentum behavior to this period price changes, then it implies that the momentum behavior affects the housing market greatly.

Since the momentum effect leads housing price continuously, increasing or decreasing and if the larger the proportion of $\frac{\beta_2}{\alpha-\beta_1}$, then on a larger scale (amplitude) housing price keeps increasing or decreasing at the same time. For the longer period (1/frequency), housing price keeps increasing or decreasing. As for the proportion of $\frac{\alpha}{\alpha-\beta_1}$, it does not capture the sum of the competing effects from the disposition and momentum behaviors in the housing market, so the trend of amplitude and frequency changes are ambiguous with this parameter.

Proposition 4. Keeping other relevant parameters invariant, the speed of amplitude decrease increases while the duration of convergence to the equilibrium is shorter in line with the increase of the disposition coefficient α or the mean reversion parameter $\tilde{\beta}$.

Based on Equation (5.7), the damped ratio ς in my model is given in Equation (5.17).

$$\varsigma = \frac{\beta_2 - \beta_1}{2\sqrt{\beta_2(\alpha-\beta_1)}} = \frac{\tilde{\alpha} - \tilde{\beta} + 1}{2\sqrt{\tilde{\alpha}}}$$

(5.17)

It becomes reverse to the disposition coefficient α and mean reversion parameter $\tilde{\beta}$, while keeping other parameters invariant, with the increase of α or $\tilde{\beta}$, then the damped ratio ς decreases. Specifically, the damped ratio characterizes the time length of price that is converging to its long-term equilibrium level. If housing prices increase, the disposition-prone investors tend to sell their housing units, which increase the market supply and increasing prices will be restrained. The larger the disposition coefficient α, then the greater the strength of its counteraction to the housing price fluctuations, i.e. the less time that housing prices need to be back to the long-run equilibrium level. More intuitively, in the autocorrelation and mean reversion domain, the larger mean reversion parameter $\tilde{\beta}$ and then the faster that prices need to move back to equilibrium, i.e. the smaller the damped ratio ς.

5.4 The Model Estimation

In the foregoing sections, we analyze and categorize the dynamics of the difference equation. The specific definitions for the four types of the dynamics are provided accordingly. We also relate the basic features (for e.g. amplitude and frequency) to the composite parameters of autocorrelation and mean reversion under the disposition-momentum behavioral theory. In this section, the aim is to empirically estimate the autocorrelation and mean reversion parameters in the derived difference equation, namely to test the difference for the different periods of shocks to the local economy. The difference is meant to examine those points, determined by different values of $\tilde{\alpha}, \tilde{\beta}$ from different periods that would appear in different Regions as in Fig 5.4. Such an investigation is conducted in the context of the Singapore private housing market.

Referring to Capozza et al. (2004), our empirical investigation is developed in two stages. First, we estimate the reference point P_t^* in the difference equation. Secondly, we estimate the adjustment relationships, allowing for partial adjustment, autocorrelation and mean reversion.

To estimate the parameters $\tilde{\alpha}, \tilde{\beta}$ in Equation (5.14), P_t^* is important. $P_t^* = f(X)$, where X is a vector of independent variables taking into account economic conditions. Hence, the key consideration lies in the selection of $P_t^* = f(X)$. Many relevant studies adopt a reduced form price equation and estimate it, based on some underlying notion of the determinants in the context of supply and demand. Generally, the fitted regression of housing price on a set of the potential determinants is interpreted to be the price level justified by fundamentals factors (forces) within the economy. The priori and important factors are sometimes insignificant or have opposite signs or are significant. The finance-based approach features an underlying notion of arbitrage, typifying the ratio of rental income to house prices as a standard metric. However, the underlying supply and demand factors, like income, are not modeled. In addition, the adjustment path of housing prices compared to their fundamental level is beyond this approach. Recent theoretical models even highlight that borrowing can make asset prices more sensitive to fundamental shocks (see Lamont and Stein, 1999). Housing loans and housing prices are interdependent in the long run and they have a positive contemporaneous impact on each other in the short run in Gimeno and Martínez-Carrascal (2006). Moreover, the variable mortgage rate is found to be important in influencing the growth rate of housing prices (Otto, 2007). Income and interest rate can explain housing price movements through time (Case and Shiller, 2003). Therefore, a hybrid method from McQuinn and O'Reilly (2008) is selected for this paper, as their model captures the significant roles of credit, income and interest rate to be drivers of housing demand in Equation (5.18)[49].

$$HL_t = kY_t\left(\frac{1-(1+R_t)^{-\tau}}{R_t}\right) \tag{5.18}$$

, where HL_t is the amount of housing loan that can be borrowed in period t; k is the proportion of household income that goes into mortgage repayments; Y_t is disposable income per household; R_t is mortgage interest rate; τ is the duration of mortgage. After nesting Equation (5.18) for the purposes of a general housing market model, the resulting expression is simplified in Equation (5.19)[50]

$$P_t^* = \zeta + \psi X_t \tag{5.19}$$

, where X_t is defined as the time-varying component of HL_t.

Two advanced regression models are adopted to estimate long-run equilibrium prices in Equation (5.19). They are the dynamic ordinary least squares (DOLS) model of Stock and Watson (1993) and the fully-modified OLS (FM-OLS) of Phillips and Hansen (1990). Recently, the single equation DOLS approach has been popular in different models on the housing market studies, such as those by Muellbauer and Murphy (1997), Fitzpatrick and McQuinn (2007) and McQuinn and O'Reilly (2008). The potential correlation between the explanatory variables (factors) and the error process are explicitly permitted in the DOLS model. The expression is

$$y_t = a_0 + a_1 x_{it} + \sum_{j=-k}^{k} \phi_{ij} \Delta x_{i,t+j} + \varepsilon_t \tag{5.20}$$

[49] Some symbols are changed to keep being consistent nor to add more confusion with the ones in this study.

[50] See page 380 in McQuinn and O'Reilly (2008) for the linear format and the detailed deduction.

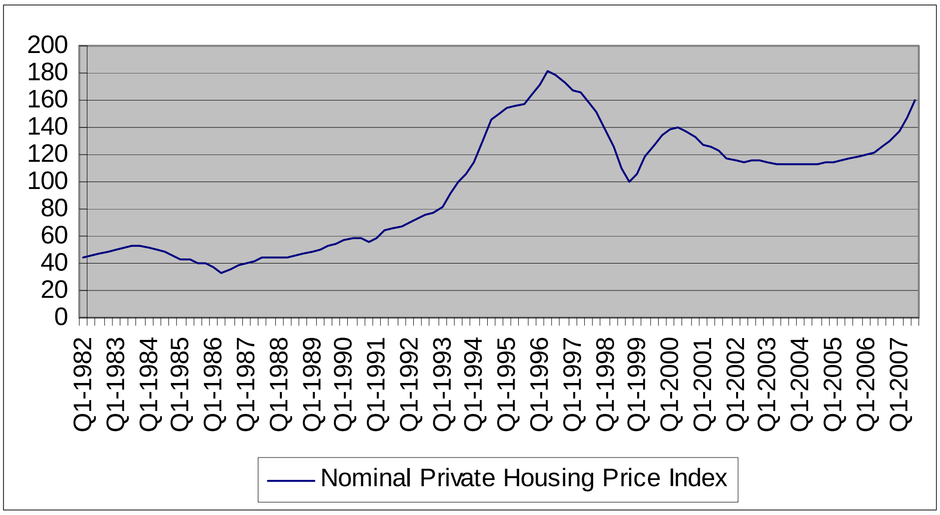
, where x_{it} is endogenous. As shown in Equation (5.20), and to correct for correlations, the DOLS involves the leads and lags of the differenced regressors in the specification. The FM-OLS is more complex and its advances lie in correcting the OLS for possible serial correlation and for endogenity in the regressors, caused by the existence of a cointegrationg relationship.

5.5 Data Source and Management

The data set for this Chapter includes three time series: nominal private housing price index, average monthly nominal earnings per employee and the variable housing loan rate for 15 years. The data is quarterly and spans 1982 Q1 to 2007 Q3. Quarterly disposable income of household is not available for Singapore and the average monthly nominal earnings per employee from all industries are selected as a proxy (Fig 5.6(b)). The percentage of housing in the household expenditure is 22% (SingStat, 2005), which is well below the widely accepted and cautious notion that the average monthly nominal earnings per employee should exclude the CPF (the central provident fund form of social security), for Singaporeans, and that the average proportion of earnings going into housing loan repayments should not exceed 30%[51]. The housing variable loan rate is selected in that it captures the economy changes better than the fixed one. The amount of housing loan is obtained from Equation (5.18).

[51] This is calculated presumably based on the relevant reports from Singstat. In this study, I set it to 30%. In McQuinn and O'Reilly (2008), the value is also 30% for the Irish setting.

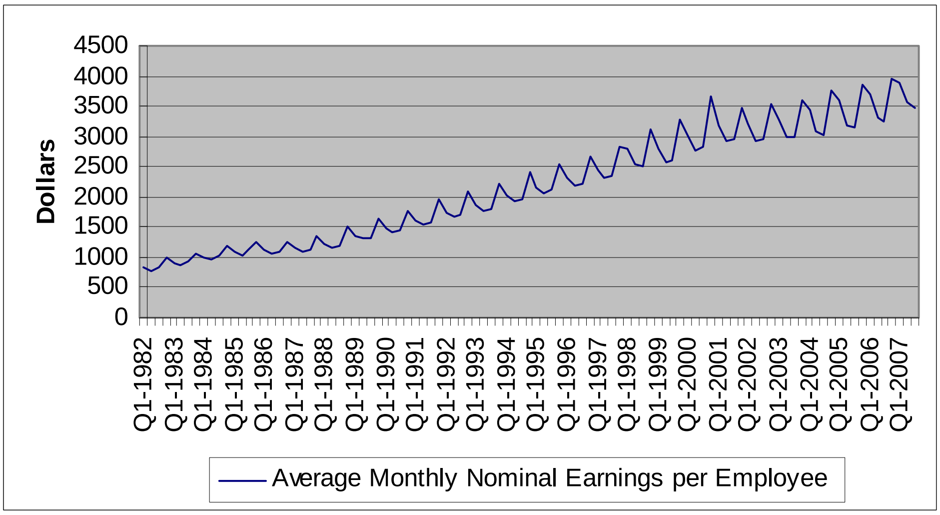
(a) Price Index of Singapore Private Housing Properties



(***Source:*** Singapore Urban Redevelopment Authority (URA), 2008)

NB. 1998 Q4 = 100; the nominal price index is computed based on fixed weights before 1998 Q4; the weights used to compute the index are updated every quarter from 1998 Q4. URA published the data named residential price index, which is referred to as nominal private housing price index in the text.

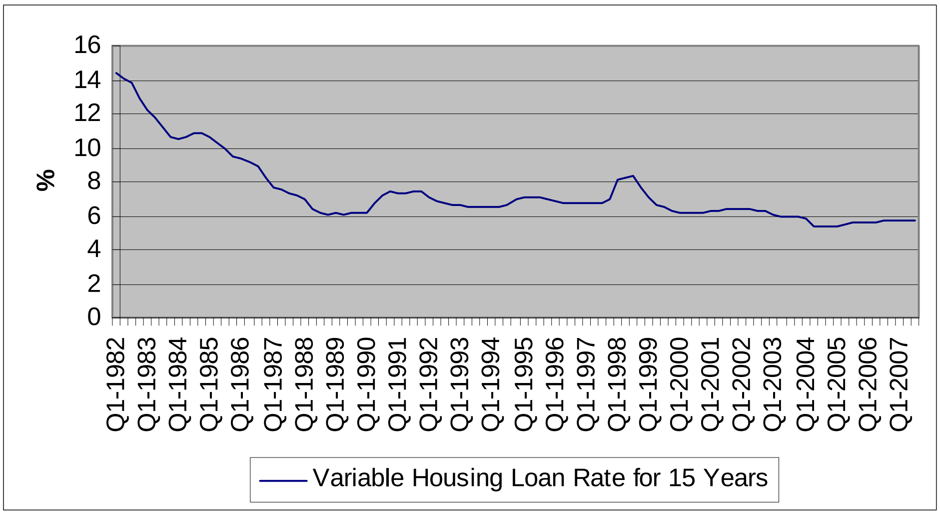
(b) Singapore Average Nominal Earnings per Employee



(***Source:*** Singapore Ministry of Manpower, 2008)

NB. The series is computed using data from the Central Provident Fund (CPF) Board and complied using 5-digit fields instead of 4-digit from 1998; it includes bonuses, if any, but excludes employers' CPF contributions; it pertains to all full-time and part-time employees who contribute to the CPF, but excludes all identifiable self-employed persons from 1992.

(c) Singapore Variable Housing Loan Rate for 15-year



(***Source:*** Monetary Authority of Singapore, 2008)

NB. Refer to average rates compiled from that quoted by 10 leading finance companies.

Fig 5.6 Housing prices, Earnings and Housing Loan Rates

5.6 Empirical Results and Analysis

Preliminary Tests and Long-Term Equilibrium Estimation

In preparation for the DOLS and FM-OLS regressions, the unit root in both logarithmic levels and logarithmic levels of the first differences for each variable are tested. The ADF test, DF-*GLS* test (Generalized Least Square) and the PP test (Phillips-Perron test) are conducted, with the results reported in Table 5.1 for the log level of the private housing price index and the housing loan. All the cases fail to reject the unit root hypothesis at the 1% level of significance, and for the log level of the first differences almost all tests reject the unit root hypothesis at the 1% level of significance.

Table 5.1 Unit Root Tests

	Private Housing Price Index	Housing Loan	1%	5%	Stationary
Level & Intercept					
ADF *t-test*	-0.962444	-3.451981	-3.496346	-2.890327	no
DF-*GLS*	-0.105344	0.576820	-2.588059	-1.944039	no
PP-*GLS*	-1.310896	-2.236825	-3.495677	-2.890037	no
1st Difference & Intercept					
ADF *t*-test	-4.054874	-3.654536	-3.497029	-2.890623	yes
DF GLS	-3.968915	-1.781768*	-2.588059	-1.944039	yes
PP GLS	-4.066967	-41.90499	-3.496346	-2.890327	yes

NB. For the ADF, DF tests, the lag length for the test regressions was chosen using Ng and Perron's Modified AIC procedure; the maximum lags are eight; keeping all these settings consistent, I also do the tests based on Trend and Intercept, all the results report the I(1) process. * shows the I(1) process at the 10% level of significance with critical value (-1.614487).

Table 5.2 Cointegration Tests for Private Housing Price Index & Housing Loan

Johansen tests	**Hypothesized no. of cointegration equation**		**5% critical values**	
	None	**At most 1**	**None**	**At most 1**
No intercept or trend				
Trace Stat.	19.63140	3.548432	12.32090	4.129906
Max-Eig. Stat.	16.08297	3.548432	11.22480	4.129906
Intercept and no trend				
Trace	27.89905	4.560768	20.26184	9.164546
Max-Eig. Stat.	23.33828	4.560768	15.89210	9.164546
Intercept and trend				
Trace	23.85785	3.626623	25.87211	12.51798
Max-Eig. Stat.	20.23122	3.626623	19.38704	12.51798
Summary of Johansen tests	**Selected (0.05 level) number of cointegrating relations by model**			
Data trend	None	None	Linear	
Test type	No Intercept, No Trend	Intercept, No Trend	Intercept, Trend	
Trace	1	1	0	
Maximum Eigenvalue	1	1	1	
Engle-Granger Cointegration Test		**5% Critical Values**	**10% Critical Values**	
Stat.	-3.50334	-3.40	-3.09	

The correlation between the actual private housing price index and housing loan is 0.704181, and 0.812251 in the logarithm form, implies a long run relationship between both series. The cointegration tests are presented in Table 5.2, and to avoid spurious results from a single test, the Johansen and the Engle-Granger (1987) cointegration tests are conducted for a robust conclusion. From Table 5.2, results from the Johansen tests provide evidence of one cointegrating vector at the 5% significance level, while the Engle and Granger test rejects the null hypothesis of no cointegration at the 5% level.

Table 5.3 Long-run model DOLS, FM-OLS and OLS estimates

Variable	DOLS estimate	FM-OLS estimate	OLS estimate
Constant	0.76102*** (0.56707)	0.72791*** (0.50253)	0.75251* (0.08525)
Log of Housing loan	0.62063** (0.27091)	0.62772** (0.25855)	0.61562* (0.04399)
R^2	0.66975	n.a.	0.65975

NB. Values in parenthesis are standard errors of each estimate; for both DOLS and FM-OLS; standard errors are adjusted for long-run variance and R^2 is centered R^2; the R^2 of FM-OLS is not calculated because it doesn't make any sense in a cointegrating regression; the results of DOLS, OLS are from the RATs 7.0 program; the FM-OLS is from the Matlab program. * denotes significance at the 0.001 level; ** denotes significance at the 0.05 level; *** denotes significance at the 0.2 level.

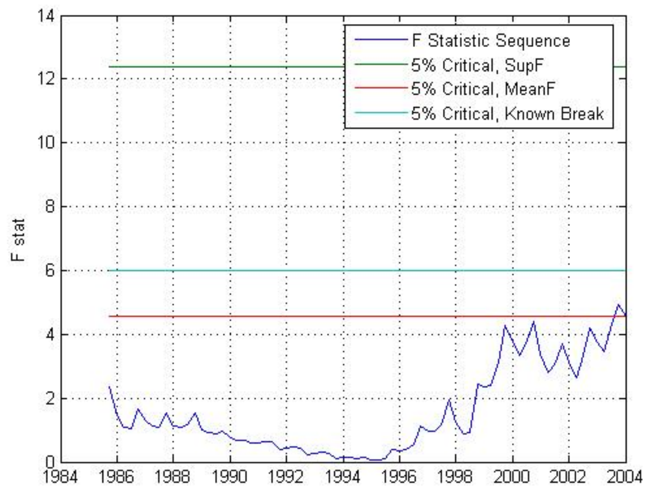
Since "the DOLS estimator falls under the single-equation Engle Granger (1987) approach to cointegration while allowing for endogeneity within the specified long-run relationships" (McQuinn and O'Reilly, 2008), the above cointegration results enable us to proceed to the DOLS regression. Table 5.3 reports the results from the DOLS, FM-OLS and OLS for the housing price index and housing loan in the long run. As expected, the estimators from each method correspond closely to the ones from other methods. The coefficient of the housing loan shows the expected sign. In particular, the housing loan calculated from the housing loan rate and average earnings as a proxy for the determinants of housing demand under certain economy conditions, is positively and significantly related to private housing price.

Furthermore, the parameter stability for equations containing the I(1) processes is investigated under the method by Hansen (1992)[52]. The results of the FM-OLS estimators are presented in Table 5.4. All test statistics fail to reject the null hypothesis of parameters' stability at the 5% significance level, as shown in Fig 5.7.

Table 5.4 Applying Hansen (1992) Test of Parameter Stability in Regression with I(1) Series

	Stability Test Stat.	P value of rejecting stability null*
LC	0.132069	0.200000
MeanF	1.587623	0.200000
SupF	4.916557	0.200000

NB.* $p >= 0.200000$ is restricted to $p = 0.200000$; the estimation in Table 5.4. and Fig 5.7 are obtained using Matlab code programmed by Professor Bruce Hansen; the pre-whitened, Bartlett kernel are adopted for each test.



(***Source***: Author, 2008)

Fig 5.7 Hansen's Stability Tests for Private Housing Price upon Housing Loan, 1982 Q1 - 2007 Q3

52 More details can be found in Gregory and Hansen (1996).

Dynamic Responses Estimation

Primarily because "The dynamic properties of housing market are specific to the given time and location being considered" (Capozza *et al.,* 2004), the theoretical model in this chapter is consistent and it implies that different markets may or may not show the same dynamic characteristics during the same period, or that the same market may or may not show the same dynamic characteristics during different periods. Hence, in this study, the Singapore housing price dynamics are investigated for two periods: the whole sample period from 1982 Q2 to 2007 Q3, and the sub-period from 1990 Q1 to 2001 Q1 when the 1997 Asia Finance Crisis occurred and housing prices experienced a large boom-and-bust for a speculative market. Using the results from the equilibrium estimation, and based on the DOLS for the whole and sub-period samples, equation (5.14) is estimated together with the form proposed by Capozza *et al*. (2004) in equation (5.21), adopting the OLS.

$$\Delta P_t = \sum_i \tilde{\alpha}_i (X_{it} - \overline{X}_i)\Delta P_{t-1} + \sum_i \tilde{\beta}_i (X_{it} - \overline{X}_i)(P^*_{t-1} - P_{t-1}) + \tilde{\eta}\Delta P^*_t \qquad (5.21)$$

In this study, $X_t = HL_t$ and $\tilde{\eta} = \tilde{\beta} + \tilde{\gamma}$.

The results are reported in Table 5.5. First, for both periods, $\tilde{\eta}$ denotes the contemporaneous adjustment of prices to current shocks and $\tilde{\alpha}$ represents the serial correlation. According to efficient market theory, $\tilde{\eta}$ should be 1 and $\tilde{\alpha}$ would be zero. However, several studies obtain the series correlation of housing price dynamics to be more than zero, such as 0.25 to 0.5 by Case and Shiller (1989) for four cities; 0.4 for a panel of 29 cities with 0.2 for the inland cities and 0.5 for the coastal cities in Abraham and Hendershott (1993); around 0.45 for 15 OECD countries in Englund and Ioannides (1997); -0.2 to 1.7 for 992 metro area in Capozza, *et al*. (2004). In this chapter's study, $\tilde{\alpha}$ is significant at around 0.7, which is consistent with existing studies. $\tilde{\eta}$ is almost zero with a large p-value, suggesting that during both periods, almost 100% of housing price adjustments occur gradually over time. Both values of $\tilde{\alpha}$ and $\tilde{\eta}$ imply that the Singapore private housing market is inefficient from 1982 to 2007. With regard to the mean reversion parameter $\tilde{\beta}$ [53], no theory predicts its estimated value (Capozza *et al*., 2004). However, if housing prices converge to their equilibrium values in the long run, $\tilde{\alpha} > 0$ implies $\tilde{\beta} > 0$ [54] (Capozza *et al*., 2004). In this chapter's study, the pairs of $\tilde{\alpha}$ and $\tilde{\beta}$ in Table 5 are significant and consistent with previous observations. Owing to the zero value of $\tilde{\eta}$, actual prices converge between 2.3% (0.022769) to 2.8% (0.028456) according to the value of $\tilde{\beta}$ of the total adjustment every year during the period 1982 to 2007; and 3.4% (0.033671) to 3.5% (0.035273) during the shorter period 1990 to 2001 compared to the higher 25% by Capozza *et al.,* (2004). Our findings are consistent with

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[53] Here, $\frac{\alpha}{\alpha - \beta_1} = \tilde{\beta} = 0.02$ is controversial relating to the hypothesis that sets α , β_1 are positive. I explain this issue from two perspectives. It is about the alternative hypothesis; one possible reason lies in the policy effect, which is excluded by the hypothesis, plays an important role in the Singapore housing market. The other is the market clearing condition. Such a condition is theoretical, in reality; the real estate market is disequilibrium for most of time (see Riddel, 2004; Ho, 2006).

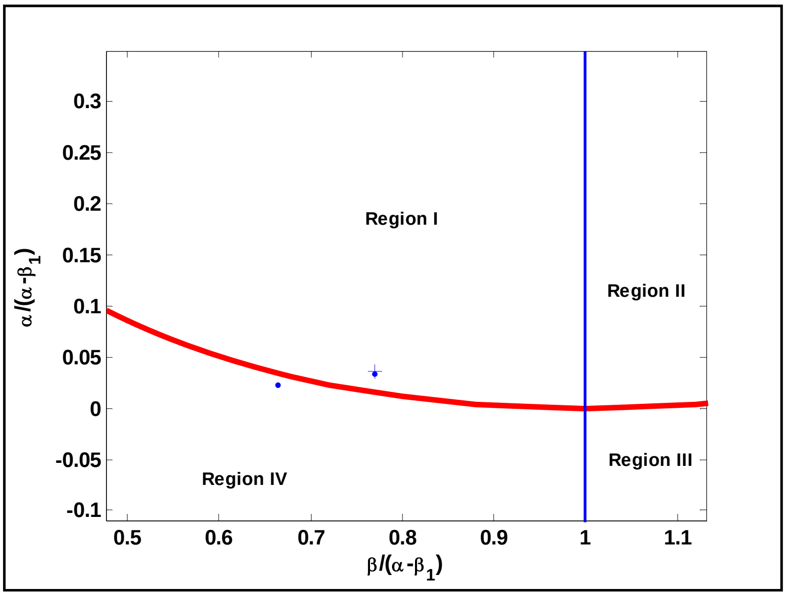
[54] This implication also can be deduced from the Disposition and Momentum Model: since all the parameters, α, β_1, β_2 are supposed to be positive, the $\tilde{\alpha}, \tilde{\beta}$ must share the same sign with each other. Hence, if one is positive, then the other one is positive, too.

those of Abraham and Hendershott (1996), who report the value of zero for Midwest cities in the U.S.

Results from Equation (5.21) in Table 5.5 shed light on the endogenous adjustments of housing price dynamics. The changes of housing loan[55] takes into account their impact on the autocorrelation and mean reversion parameters, denoted as $\tilde{\alpha}_1, \tilde{\beta}_1$. However, for the whole and sub-periods, $\tilde{\alpha}_1$ and $\tilde{\beta}_1$ are statistically insignificant with high probability values in Table 4.5. Thus, the changes of housing loan do not lead to statistically significant differences in serial correlation and mean reversion for Singapore's private housing price dynamics. It implies that housing loan, representing economic conditions, affect housing price dynamics via totally entering the equilibrium price P_t^* for the private housing market in Singapore. Our model offers a stylized investment market where fundamental housing value changes exogenously. It means that housing price dynamics should be explained beyond general economic conditions, providing support for the Equation (5.14) on the basis of the disposition and momentum behavioral theory. On the locations of the points determined by $\tilde{\alpha}$ and $\tilde{\beta}$ and are plotted in the 'Region' map (see Fig 5.8), it is clear that for the whole sample period, housing price dynamics lie in Region IV (convergent but no oscillations). However, for the shorter sub-period, both the different models point towards Region I (Convergent and with Oscillations). It can be concluded that for the longer run from 1982 to 2007, Singapore's housing price dynamics is convergent to equilibrium prices without oscillations (being over-dampened). For the

[55] The changes of housing loan rate and earnings are also considered but not reported. Their impact on the autocorrelation and mean reversion parameters keeps consistency with that for housing loan.

sub-period from 1990 to 2001, the Singapore private housing market is deemed to be speculative but with housing prices fluctuating still in a convergent and oscillating manner, without showing divergence. Moreover and according to Capozza *et al.* (2004), only 70 of the 992 metro areas (around 7%) lie in the divergent range with an autocorrelation parameter exceeding 1. The largest one is 1.7. So, for Singapore, the autocorrelation parameter of 0.77 for the sub-period or an even smaller parameter of 0.66 for the whole sample period, are far from the divergence region with an autocorrelation parameter from 1 to 1.7. It implies that the Singapore private housing price dynamics is far from being a speculative price bubble.



(***Source***: Author, 2008)

NB. The dot below the line is obtained from the regression based on Equation (4.21) for the whole sample period, since the model of Equation (4.21) has a higher R^2 value than that of Equation (4.14); two dots and a positive sign above the line are obtained from the regression based on Equation (4.14) and Equation (4.21) for the shorter sub-period.

Fig 5.8 Parameters Allocation in the Region Map

According to Proposition 1, and under our disposition and momentum framework, every pair of significant $\tilde{\alpha}$ and $\tilde{\beta}$ shows the positive sign and it deduced that $\alpha > \beta_1$. Our results show that the housing price dynamics lies in Region IV for the whole sample period, as it should be in Proposition 2, Case (2) a, i.e. $\beta_1 < \beta_1 + \beta_2 < \alpha < \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$. Thus, the Singapore private housing market is strikingly dominated by the disposition-prone investors, compared to the momentum-prone investors during the long run period 1982 to 2007. So in the long run, the housing price dynamics shows convergence to equilibrium. In terms of the shorter sub-period, the housing price dynamics lies in Region I, which corresponds to the situation in Case (2) b, i.e. $\alpha > \frac{(\beta_1 + \beta_2)^2}{4\beta_2}$ and $\alpha > \beta_1 + \beta_2$. Once again, the disposition-prone investors dominate, compared to the momentum-prone investors, even in to the so-called speculative period (1993-1996, 2000-2001), where the housing price dynamics do not show divergence. Our results here are consistent with those of extensive domestic sources, such as the financial advisory firms, online comments and academicians. For example, at the IPAC (2007) panel, three presentations reiterate that the housing price bubble is not in the offing[56]. Tilak Abeysinghe[57] (2007) mentions that the rise in housing prices is below the market's long-run equilibrium level, i.e. the pace of housing price rises is still below the level that would be expected based on market fundamentals. Since α is larger than $\frac{(\beta_1 + \beta_2)^2}{4\beta_2}$ in the shorter sub period and is smaller in

[56] See the lushhomeonline comment entitled "Analysts see no property bubble" at http://lushhomemedia.com/category/property-bubble/

[57] The paper, Singapore's Property Market And The Macro-economy, can be viewed at http://nt2.fas.nus.edu.sg/ecs/cent/ESU/conference.htm. News Source: Straits Times - 19 Oct 2007.

the long run whole sample period, the comparative magnitude of α to β_1, β_2 for the sub period is larger than that for the whole sample period. In Table 4.5, the value of $\tilde{\beta}$ of the subperiod is slightly larger than that of the whole sample period. According to Proposition 4, the larger α or $\tilde{\beta}$ contributes to faster recovery. It thus offers the explanation for faster recovery of the boom and bust in the period from 1990 to 2000, compared to the whole period from 1982 to 2007. The value of $\tilde{\alpha}$ of the shorter sub period is larger than that of the whole sample period, according to Proposition 3, where the amplitude of the upturn in the period from 1990 to 2000 is higher. Thus, by combining the estimates of α and $\tilde{\alpha}$, from Proposition 4 and 3, it provides the explanation for the boom and bust during 1990 to 2000 in terms of the autocorrelation-mean reversion and investors' behavior. In short, Singapore's private housing boom in the period from 1990 to 2000 differs from other upturns in the period from 1982 to 2007: the recovery from the bust in the period from 1990 to 2000 is faster and the magnitude of price gain is significantly higher. These characteristics are consistent with the analysis of Morgan Stanley (2007) on Singapore's housing market.

Table 5.5 Price Dynamic Responses Regressions

Total sample period: 1982 Q2 to 2007 Q3						
	Equation (5.14)			Equation (5.21)		
Coefficient	Estimator	T-Statistic	Prob.	Estimator	T-Statistic	Prob.
$\tilde{\alpha}$	0.720693*	10.39657	0.0000	0.664241*	7.354956	0.0000
$\tilde{\alpha}_1$				0.311927	0.939295	0.3499
$\tilde{\beta}$	0.028456**	2.467161	0.0154	0.022769***	1.662494	0.0997
$\tilde{\beta}_1$				0.037357	0.698569	0.4865
$\tilde{\eta}$	-0.008330	-0.179298	0.8581	-0.006417	-0.137423	0.8910
R^2	0.514007			0.519831		
Subperiod: 1990 Q1 to 2001 Q1						

	Equation (5.14)			Equation (5.21)		
Coefficient	Estimator	T-Statistic	Prob.	Estimator	T-Statistic	Prob.
$\tilde{\alpha}$	0.770719*	8.036512	0.0000	0.770683*	7.788238	0.0000
$\tilde{\alpha}_1$				-0.627995	-0.582453	0.5635
$\tilde{\beta}$	0.035273***	1.867265	0.0689	0.033671***	1.671325	0.1025
$\tilde{\beta}_1$				-0.007312	-0.029771	0.9764
$\tilde{\eta}$	-0.049101	-0.626750	0.5342	-0.049797	-0.612001	0.5440
R^2	0.576767			0.580697		

NB. $\tilde{\alpha}_1, \tilde{\beta}_1$ are the changes of housing loan plus autocorrelation and mean reversion, respectively. * Denotes significance at the 0.001 level; ** Denotes significance at the 0.02 level; *** Denotes significance at the 0.1 level.

Housing price dynamics can be different in different periods and from the findings of Cappozza *et al*. (2004), 26% of observed housing price dynamics exhibit the convergence with no oscillation (i.e. in Region IV) while 67% exhibit convergence with oscillations (i.e. in Region I), and with zero% lying in Region III. Hence, Singapore's housing price dynamics, while it is accordingly consistent, its uniqueness is attributed to the different types of price dynamics that correspond to different periods. In the longer period (1982 to 2007) for Singapore's case, the damped convergence is a reaction to price shocks (in Region IV) while in the shorter period and inclusive of the "speculative" period (1990 to 2001), then the damped oscillations are the reaction to price shocks (in Region I). Lastly and although the impact of the public policy effect is excluded in our paper, it is deemed to be part of investors' behavior, i.e. policy acts as an exogenous variable and it does not affect the model structure. This is primarily because the Singapore government has regularly and strongly intervened in the housing market for the overall aim of housing price stabilization[58] [59]. Thus, the over-dampened convergence of the Singapore housing

[58] Singapore government policy on property market since 1960 is listed in Appendix 5.4

price dynamics is caused by the aggregate effects of the behavior of the disposition-prone and momentum-prone investors' behavior, and of government policy in the long run.

In the recent literature, there exist theoretical explanations and empirical results that are consistent with this chapter's study, pertaining to the links between agents' behavior and the price dynamics on the aggregate market. It is useful noting that "An important challenge to behavioral finance is to find a direct link between individual investor behavior and asset price dynamics. Few doubt that large numbers of investors behave irrationally and are prone to behavioral heuristics that lead to sub optimal investment choices, however the empirical evidence that these investors affect prices has been elusive" (Goetzmann and Massa, 2003).

As for the widely documented disposition effect, Statman and Thorley (1999) point out that the disposition effect is stock-specific rather than it being related to the market as a whole. The disposition effect may not even manifest itself as a pervasive, market wide risk factor. However, Goetzmann and Massa (2003) test this proposition and obtain the evidence that "trade between disposition-prone investors and their counter-parties influences relative prices". They conclude that "both volume and volatility may depend in general upon the composition of the market, and more specifically on disposition-prone investors".

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[59] "The government will continue to monitor the residential property market in a bid to ensure that prices remain stable, according to National Development Minister Mah Bow Tan", Lushhome :: Online news and information on Singapore property market (2008). http://lushhomemedia.com/category/property-bubble/

Actually, the so-called “counter-parties” denote the momentum-prone investor in our study, and our study is consistent with that by Goetzmann and Massa (2003). In a future study, it may well be interesting to relax the extreme assumptions imposed on our theoretical model in order to consider the unique features of housing real estate.

5.7 Robustness Checks

To enable the robustness of our results, a number of alternative specifications are attempted in terms of six specific cases. The first case is concerned with the price dynamic response regressions for the shorter relative to the equilibrium results from the DOLS for the same period. Although R^2 becomes higher, the values of $\tilde{\alpha}$, $\tilde{\beta}$ are consistent with the earlier results. Secondly, because new housing supply in the whole sample period is limited[60], N in Equation (5.3) is set to zero. The third case is concerned with the proportion of income to mortgage payment, and it is adjusted and to a lower proportion of 26%. In the fourth case, the data is seasonally adjusted adopting the Census X12 statistical mode. The fifth case pays due attention to certain variables in real terms to explain economic phenomena. The sixth case adjusts the data set in real terms. All results of the long-run equilibrium that are not reported in the tables are very similar to Table 5.3. All results of the dynamic response regressions for the six different cases are provided in Table 5.6. It is clear that the variables in real terms exhibit less serial correlation and similar mean reversion compared to the nominal ones, suggesting the likelihood of less overshooting. The seasonally adjusted data compared to the unseasonally adjusted data shows the same trend. However, for the whole sample period, the points determined by $\tilde{\alpha}$,

[60] See Appendix 5.5 for the detailed trend.

$\tilde{\beta}$ from equation (5.21) are associated with a higher R^2, compared with Equation (5.14) and all are located in Region IV (convergence but with no oscillations). It is interesting that all points determined by $\tilde{\alpha}$, $\tilde{\beta}$ from equation (5.14) lies close to the oscillations critical line. In terms of the shorter sub-period, both equations exhibit similar results and all the points are located in Region I (convergence and with oscillations). On the whole, the results are robust with respect to the main features of Singapore's private housing price dynamics.

Table 5.6 Robust Checks of Price Dynamic Responses Regressions

Total sample period: 1982 Q1 to 2007 Q3												
	Case 1.		**Case 2.**		**Case 3.**		**Case 4.**		**Case 5.**		**Case 6.**	
	Based on subperiod sample		**N=0**		**k=26%**		**k=30%, Nominal, SA**		**k=30%, Real**		**k=30%, Real, SA**	
	Equation (4.14)	**Equation (4.21)**	**Equation (4.14`)**	**Equation (4.21`)**	**Equation (4.14)**	**Equation (4.21)**	**Equation (4.14)**	**Equation (4.21)**	**Equation (4.14)**	**Equation (4.21)**	**Equation (4.14)**	**Equation (4.21)**
$\tilde{\alpha}$	n.a.	n.a.	0.72	0.66	0.72	0.66	0.69	0.59	0.70	0.65	0.67	0.58
$\tilde{\beta}$	n.a.	n.a.	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.03
The selected subperiod: 1990 Q1 to 2001 Q1												
	Case 1.		**Case 2.**		**Case 3.**		**Case 4.**		**Case 5.**		**Case 6.**	
	Based on subperiod sample		**N=0**		**k=26**		**k=30, Nominal, SA**		**k=30, Real**		**k=30, Real, SA**	
	Equation (4.14)	**Equation (4.21)**	**Equation (4.14`)**	**Equation (4.21`)**	**Equation (4.14)**	**Equation (4.21)**	**Equation (4.14)**	**Equation (4.21)**	**Equation (4.14)**	**Equation (4.21)**	**Equation (4.14)**	**Equation (4.21)**
$\tilde{\alpha}$	**0.75**	**0.73**	**0.75**	**0.75**	**0.77**	**0.77**	**0.75**	**0.72**	**0.75**	**0.75**	**0.73**	**0.74**
$\tilde{\beta}$	0.03	0.06	0.02	0.02	0.04	0.03	0.03	0.06	0.04	0.03	0.03	0.04

NB. Equation (5.14`) is form Equation (5.14) when N=0: $\Delta P_t = \tilde{\alpha}\Delta P_{t-1} + \tilde{\beta}(P_t^* - P_{t-1})$ ; Equation (5.21`) is form Equation (5.21) when N=0:

$$\Delta P_t = \sum_i \tilde{\alpha}_i (X_{it} - \overline{X}_i)\Delta P_{t-1} + \sum_i \tilde{\beta}_i (X_{it} - \overline{X}_i)(P_1^* - P_{t-1})$$

5.8 Summary

Rooted in behavioral finance, this chapter's study offers a disposition-momentum theoretical framework to explain housing price dynamics. It allows the heterogeneous investors' assumption in the housing market to be based on a generic and rigorous modeling of behavioral housing price dynamics, and to be able to conduct the empirical study of the Singapore private housing market.

This Chapter sheds light on the behavioral explanation of the empirical estimates for housing price serial correlation and its mean reversion time path. As the model indicates, the serial correlation at one-year frequency is determined by the proportion of the momentum coefficient to the last-period price changes in the sum effect from the disposition behavior and the momentum behavior to the present-period price changes. The mean reversion over a longer period is determined by the proportion of the disposition coefficient to present-period price changes in the sum effect from the disposition behavior and the momentum behavior to this period's price changes. Therefore, the interaction (trades) between the two different kinds of investors acts as a key determinant of housing price dynamics.

Referring to the definitions by Capozza (2004) and others, I analyze the second-order difference model to identify the characteristics of housing dynamics. Four types of dynamic structure are defined by two groups of relationships among the different investors' sensitivity coefficients, i.e. damped versus cyclical and convergent versus divergent or explosive. On behavioral housing price dynamics and in terms of the different investors' sensitivity coefficients, our paper provides a more rigorous definition of "overshooting" or the "bubble" within the disposition-momentum theory. Two conditions, i.e. the complex roots obtained for the second-order difference equation and the composite serial correlation parameter exceeding one, leads to overshooting behavior. I express both conditions in term of the disposition and momentum coefficients by obtaining the consequential composite parameters. These make up one of the main differences between our paper and that by Capozza (2004).

Furthermore, the composite impacts from the different sensitivity coefficients on the amplitude and frequency of housing price dynamics. The estimation results (via the Matlab program) show that for the cyclical or oscillating housing price dynamics, the amplitude increases sharply and concussively with an increase of the composite autocorrelation parameter but that the amplitude is ambiguous in the composite mean reversion parameter. Its frequency decreases steeply with an increase of the composite autocorrelation parameter but it is also ambiguous in the composite mean reversion parameter.

In the context of the Singapore private housing market, the empirical analysis in the foregoing disposition-momentum theoretical framework shows that the serial correlation at one-year frequency is around 0.7 in both periods. The actual prices converge at only 2.3% to 2.8% of the total adjustment every year during the period from 1982 to 2007, and at only 3.4% to 3.5% during the 1990s. In the long run (1982 to 2007), the price dynamics are convergent to equilibrium prices without oscillations (being over-dampened). In the 1990s, prices fluctuate still in a convergent and oscillating way, without showing divergence. Hence, the behavioral characteristics of price dynamics vary over time for the Singapore private housing market. The effect from disposition-prone investors dominates that of the momentum-prone investors during both periods. The comparative magnitude of the disposition effect to the momentum effect is larger during the 1990s than the one in the total sample period. The value of the composite autocorrelation parameter during the 1990s is larger than that of the total sample period. Both results provide the explanation on the difference between the current upturn[61] and the one during 1990s in terms of amplitude and frequency, i.e. the magnitude of price gain being lower and recovery being gradual (Morgan Stanley report, 2007).

[61] "Despite the recent recovery, property prices in 2006 were still 28% below their peak 1996 level (33.4% in real terms)", Global Property Guide (2007) comments on Singapore residential market at http://www.globalpropertyguide.com/Asia/Singapore/Price-History

CHAPTER 6 SUMMARY AND CONCLUSION

6.1 Summary of Main Findings

Housing (real estate), as a major component of wealth for households, is prone to cyclical fluctuations, and it is therefore important to obtain an in-depth understanding of the fluctuations of housing price that affect households' consumption decisions and the overall economy. Furthermore, an insightful understanding of the characteristics of housing price dynamics, the time-series variation in housing prices and the aggregate housing market dynamics is important for attaining effective real estate investment portfolio risk management, hedging, pricing, economic and housing policy formulation.

In order to enable an in-depth investigation of housing market dynamics and its commonalities, this dissertation's study develops three unique theoretical frameworks of analysis (TFA) from three different perspectives for analyzing: (1) the cyclical association of housing price-consumption based on the augmented Slutsky equation; (2) the aggregate housing market dynamics within general equilibrium-disequilibrium theory; and (3) housing price dynamics within a disposition-momentum behavioral context. Three corresponding empirical validations are then conducted in the context of Singapore's private housing market. The findings of each TFA together with its empirical validation are consequently summarized below.

First, a TFA is developed in this dissertation's study to explain the consumption expenditure changes brought about by changes in housing prices. The framework focuses on the wealth effect taking into account the dual characteristics of housing real estate in terms of being both a consumable good and an investment asset. Different from the Slutsky equation and as it appears in standard texts on microeconomic theory, the impact of housing price variation on consumption contains the income and substitution effects together with the additional terms defined as the “expectation effect” (Dusansky and Wilson, 1993; and Dusansky and Koc¸, 2006). This expectation effect operates through the capital gain effect.

From a cyclical perspective, this dissertation’s study investigates the association between housing price and consumption through the adoption of spectral and cross-spectral density models. For the total sample period, the spectral analysis shows that both housing price and consumption experience a major cycle at approximately 25.5 quarters (more than six years), with variations of 33.68% and 25.99%, respectively. Compared with consumption, housing price performs cyclically and stronger in the long run. According to the cross-spectral analysis where low frequencies (from 9.27 to 102 quarters) indicate that the mid and long run demonstrate relatively high coherency, then in the mid and long run, housing price and consumption are closely linked and show clear alternate lead-lag relationships. High frequencies (from 2 to 8.5 quarters) indicate the short run, where there is weak evidence for cyclical relationships between the two series in the short run, albeit with clear alternate lead-lag patterns. Furthermore, direct Granger causality cannot be established between housing price and consumption.

The results from the typical period (1996:Q1–2001:Q4), which reflect Singapore's speculative housing market, do provide clear evidence that the expectation effect operating throughout the capital gain effect helps to explain the housing price effect on consumption along the housing price cycles. Results from the recessionary period (1996:Q1–1998:Q4) and the expansionary period (1999:Q1–2001:Q4) suggest that the expectation effect is larger during an expansionary period than during a recessionary period. Thus, housing price affects consumption significantly, depending on the time scale and frequency without a consistent sign. Consequently, no single number or "marginal propensity", as mentioned before, can accurately describe the response of consumption to housing price from a cyclical perspective.

Secondly, another unique TFA establishes the economic interpretation of the aggregate housing market dynamics, driven by a few number of unobservable common factors and rooted in general equilibrium theory and the associated Walrasian attunement process. The appropriate research design revolves on the FHLR (Forni, Hallin, Lippi & Reichlin) GDFM (generalized dynamic factor model) specification. The time-series variation in housing prices is robustly investigated in order to capture the state of the economy and changing housing market conditions on the whole.

In the long run period between 1988 and 2007, the estimation highlights the existence of two significant latent common factors underlying Singapore private housing market dynamics. The top and the last rankings of the commonality ratio in the macroeconomic (time) series interchange while the rankings of the housing market-wide series keeps being consistent over different panel-data sets with different weights for both series. It is quite natural to imply that one of the two significant latent common factors would arise from the macroeconomic series while the other factor would be a housing market-specific factor. This implication cannot be established without additional identification restrictions under the GDFM approach. However, this is beyond to scope of the current study. Driven by two unobservable common factors, the representative series with high degrees of commonality for the macroeconomic series and housing market series are the ones that are highly related to financial conditions, for example, the saving deposit rate, the all-share stock price index; housing loan, prime lending rate and the 15-year housing loan rate. Approximately 30% of the total variance in observed housing prices is related to housing market dynamics driven by two underlying common factors in the period between 1988 and 2007. In addition, such commonality varies over time and specifically it is higher in the period when housing prices are more volatile. Empirical estimates show that the time-series variation in housing prices only explains about 38% of the variation in the observed prices in the period between 1988 and 2007 or at about 53% during the shorter and highly volatile period between 1988 and 1998, which confirms the housing market illiquidity feature. Furthermore, the return and risk biases of the housing asset are tested and they are found to depend on their volatility characteristics during a certain period.

In terms of the last (third) TFA, a key assumption of the unique behavioral model of private housing price dynamics is that the investors are heterogeneous of the disposition-prone and momentum-prone investor types. Their decision-making shows different sensitivities to housing price changes. It sheds light on the behavioral explanation of empirical estimates for housing price serial correlation and its mean reversion time path. The interaction of the two types of investors or the aggregate effect of their behavior is found to be an important determinant of the housing price dynamics. The model permits the establishment of the composite autocorrelation and mean-reversion parameters, under which the dynamics in response to shocks, can be divided into four kinds: convergent or divergent and damped, or oscillatory, defined as overshooting or cycles by Capozza *et al*. (2004).

The empirical results in the Singapore case suggests that the housing price dynamics show different features during different periods with variant autocorrelation and mean reversion parameters: during a longer period (1982 to 2007), damped convergence is the reaction to price shocks while in a shorter and so-called "speculative" period (1990 to 2001), the price dynamics show damped oscillations rather than divergence. The characteristics of the current housing market upturn differ from those of the 1990s' boom: recovery is slower and the magnitude of the price gain is lower. For both periods, the disposition-prone investors are prevailing compared to the momentum-prone investors in the private housing market.

Moreover, the model offers a stylized investment market where fundamental value changes exogenously. It provides potential evidence that investor behavior is endogenously crucial in explaining housing price dynamics. The results show that the average autocorrelation parameter is approximately 0.7. The instantaneous adjustment parameter is almost zero with a large p-value, suggesting that during both periods, almost 100% of housing price adjustments occur gradually over time and that actual housing prices converge to only between 2.3% and 2.8% of the total adjustment each year during the period from 1982 to 2007; and to only between 3.4% and 3.5% during the period from 1990 to 2001.

On the whole and rooted in microeconomics, the first TFA (in Section 3.2) of this dissertation implies that the expectation effect plays an important role in explaining the housing price-consumption association, together with the income effect and substitution effect. Originating from behavioral finance, the third TFA (in Section 5.2) of this dissertation concludes that the interaction of the two types of investors (disposition-prone and momentum-prone) or the aggregate effect of their behavior is an important determinant of the housing price dynamics. Hence and theoretically, the two different TFA from different perspectives consistently demonstrate that households' behavior or expectations are of great importance in explaining the housing price dynamics. However, the empirical results based on the two different TFA are contrary for Singapore's private housing market. Specifically, the disposition effect dominates the momentum effect in the market during the period from 1982 to 2007; while the expectation effect is significant in explaining the housing price-consumption association for the period from 1980 to 2005. Such observations may well come from the different theoretical perspectives and reference-point selection for the disposition-prone investors in the empirical study of Chapter 5.

6.2 Theoretical Implications

According to all three TFAs developed for this dissertation's study and the corresponding empirical results in the Singapore case, several implications can be obtained.

With regard to the association of housing price and consumption, housing price affects consumption significantly, depending on the time scale and frequency without a consistent sign. The expectation effect, operating through the capital gain effect, is important in explaining the housing price-consumption relationship and contributes more during the expansion period than the recession period.

The second-order difference model within a disposition-momentum behavioral context suggests that the interactions of both types of investors (disposition-prone and momentum-prone) act as a key determinant of housing price dynamics for a given time and for a specific market. Another contribution lies in the definition on the patterns (features) of housing price dynamics under the disposition-momentum theory. Housing price dynamics are deduced and categorized through the difference model in respect of the composite autocorrelation and mean-reversion parameters under the disposition-momentum domain.

A key implication for investors is that the current boom of Singapore's private housing market does not provide as large a magnitude as that of the price gain in the 1990's boom, within a long-run perspective. Singapore's private housing market also seems to be low risk and it offers stable returns, owing to virtually no divergence even in the speculative

1990s. Since the disposition-prone investors are prevailing in Singapore's private housing market, the best way to invest is to adopt a momentum-prone investor strategy.

For policy-makers, and since the government policy plays a stabilization role in housing price dynamics[62], the Singapore private housing market is over-dampened (and without oscillations) in a long run. Furthermore, disposition-prone investors predominate this housing market, whose behavior contributes to the market mechanism in automatically adjusting housing prices. The implication is thus to relax government intervention in the Singapore private housing market to make it more efficient. In addition, the cyclical variance of housing price in the short run of approximately 2 to 8.5 quarters needs not be a serious concern, as it is a weakly cyclical co-movement with consumption. However, the cyclical variance of housing price in the mid and long run is approximately 9 to 102 quarters and deserves attention, as it is closely linked with consumption. The different gain values imply different MPC (marginal propensity to consume) within different time frames and frequency, which make them accurate enough to diagnose an overheating or bubble-like housing market. Finally, the varying magnitudes of the cyclical nature of the housing price effect should be examined further.

6.3 Recommendations for Future Research

For the first TFA, further study can be undertaken to establish and estimate the income effect, the substitution effect and the expectation effect as well as to estimate the different MPC utilizing more micro data. The foregoing theoretical model can also be extended to take into account the time trend. Moreover, as Rabin and Thaler (2001) argue, "the loss

[62] Since governments usually make policies as counter movements to the market with an aim to smooth the price dynamics from a long-run perspective.

aversion and the tendency to isolate each risky choice must both be key components of a good descriptive theory of risk attitudes.” Investigation of the different risk attitudes or the different loss probabilities is warranted, along with the trading time scale towards different cycle periods, in order to quantify the expectation effect.

For the second TFA, the study can possibly be extended to incorporate a general equilibrium framework that makes housing supply as an endogenous variable in order develop an alternative GDFM specification. It should also be interesting to investigate the quantified relationship between housing price volatility and its time-series variation if the volatility can be defined and expressed accordingly. If housing price is selected as a reference then the lead-lag and the timing of the lag properties for all other time series in a data set can be measured, relative to the reference, which ultimately sheds light on housing price discovery.

For the combination of both the second and third TFAs, a potential research design concerning either the explanation power of systematic dynamics with respect to observed housing price dynamics, or the momentum (disposition) profits of the housing asset. These can be assessed through estimating the spectrum R-square (see Tong Yao, 2008) and by adopting the common components of the housing market-wide variables in conjunction with macroeconomic variables.

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APPENDIX

Appendix 4.1 Estimating Common Components under the GDFM

Using a Bartlett lag-window estimator of size *M=M(T)* estimates the spectral density matrix $\sum(\theta), \theta \in [-\pi, \pi]$ of x_{nt}. The sample covariance matrix Γ_k^T of x_{nt} and x_{nt-k} for *k=0,…, M* are computed firstly, then the discrete Fourier transform of the truncated two-sided sequence $\Gamma_{-M}^T,...,\Gamma_0^T,...,\Gamma_M^T$ are calculated, the resulting spectral density matrix is,

$$\sum\nolimits_n^T(\theta_s) = \sum_{k=-M}^{M} \Gamma_k^T \omega_k e^{-ik\theta_s} \tag{4.1-1}$$

where, $\theta_s = 2\pi s/(2M+1), s = 0,...,2M$; the weights corresponding to the Bartlett lag-window of size *M* are $\omega_k = 1 - [|k|/(M+1)]$. The first *q* eigenvectors $\pi_{jn}^T(\theta_s), j = 1,...,q,$ of $\sum_n^T(\theta_s)$ for *s=0,…,2M* are computed. When *s=0,* the dynamic principal components is reduced to the static ones. Based on the eigenvectors, it can be computed,

$$\Phi_n^T(\theta_s) = \tilde{\pi}_{1n}^T(\theta_s)\pi_{1n}^T(\theta_s) + ... + \tilde{\pi}_{qn}^T(\theta_s)\pi_{qn}^T(\theta_s) \tag{4.1-2}$$

where tilde indicates conjugation and transposition. Lastly, the estimator of the filters $K_n(L)$ matrix is computed based on the inverse discrete Fourier transform[63] of

$$[\Phi_n^T(\theta_0),...,\Phi_n^T(\theta_{2M})],\ K_{kn}^T = \frac{1}{2M+1}\sum_0^{2M}\Phi_n^T(\theta_s)e^{ik\theta_s},\ \text{k = -M,…,M, i.e. } K_n^T(L) = \sum_{k=-M}^{2M} K_{kn}^T L^k \tag{4.1-3}$$

Thus, the estimator of the common and idiosyncratic components are given by,

$$\chi_{nt}^T = K_n^T(L)x_t \tag{4.1-4}$$

[63] The projection coefficients $b_{ij}(L)$ are the results of an inverse discrete Fourier transform of the first *q* dynamic eigenvectors. They are two-sided and both lagged and future values of the common factors can be loaded.

$$\varepsilon_{nt} = x_{nt} - \chi_{nt} \qquad (4.1\text{-}5)$$

Correspondingly, the spectral density matrix of the common components is estimated as,

$$\sum_{n}^{\chi^{T}} (\theta_s) = \Phi_n^T(\theta_s) \sum_n^T \theta_s \Phi_n^T(\theta_s) \qquad (4.1\text{-}6)$$

Appendix 4.2 An Alternative Approach for *q* Selection

Connor and Korajczyk (1993) use sequential limit asymptotes to estimate the number of *q* with $n \to N$ first, followed by *T*. Cragg and Donald (1997) suggest adopting the Bayesian information criterion to investigate the rank of a consistent estimation of the sample covariance matrix with fixed *n* and *T*. Assuming $\sqrt{n}/T \to 0$, Stock and Watson (1999) propose determining *q* by minimizing a particular information criterion[64]. Considering $(N,T) \to \infty$ under the approximate factor model, Bai and Ng (2002) develop this line by proposing a statistical procedure under which in certain conditions, the information criteria with appropriately chosen penalties[65] can consistently estimate a finite number of static factors *r*, as a trade-off between goodness-of-fit and over-fitting. The criteria give an upper bound for the number of *q* in the form of $r = q(s + 1)$, where *r* is the maximum combination of dynamic factors and *s* is the order of the lag operator. Bai and Ng (2007) further develop their earlier criterion to determine the number of dynamic factors *q* by stating precisely the relationship between *q* and *r*. They show that a

[64] However, their simulation experiments show that more standard criteria like the AIC or BIC perform better.

[65] For the stationary case, the true number of *k* can be obtained by minimizing one of the information criteria (see Bai and Ng 2002, page 201–202). In the nonstationary case, the number of factors relates to the cointegration rank in the econometrics field. Or see Bai (2004).

dynamic factor model always can be represented in a static form, thereby the dynamics of *Ft*, a vector of unobserved common factors shared by *N* series x_{it}, is characterized by a VAR. The spectrum of the static factors has rank *q* in the VAR representation. This methodology to determine the value of *q* needs not to estimate the dynamic factors.

Appendix 5.1 Solutions of the Difference Equation

In eq (5.5), actually, $P^* = P_t^*$, it is generally stochastic. In order to investigate the dynamic characteristics of the difference equation from an illustrative case, let $P_t^* = P^*$, a constant and $P_0 \neq P^*$.

Initial Conditions,

Let $P(0) = P_0$ ($P_0 \neq 0$), then from eq (5.5), it can be obtained,

$$P(1) = \frac{\beta_1 P_0 - N - \alpha P^*}{\beta_1 - \alpha} \tag{5.1-1}$$

The roots of the characteristic equation are,

$$\lambda_1, \lambda_2 = \frac{1}{2}\left[\frac{\beta_1 - \beta_2}{\beta_1 - \alpha} \pm \sqrt{\frac{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}{(\beta_1 - \alpha)^2}}\right] \tag{5.2-2}$$

Case (1). Distinct Real Roots: $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 > 0$

$$P_t = A_1\lambda_1^t + A_2\lambda_2^t + P^* + \frac{N}{\alpha} \tag{5.2-3}$$

Where, $A_1, A_2 = \frac{1}{2}(P_0 - P^* - \frac{N}{\alpha})\left[1 \pm \frac{\beta_1 + \beta_2}{(\beta_1 + \beta_2)^2 - 4\alpha\beta_2}\right]$

Case (2). Repeated Real Roots: $(\beta_1+\beta_2)^2-4\alpha\beta_2=0$

$$P_t=(A_3+A_4t)+\left[\frac{\beta_1-\beta_2}{(2\beta_1-\alpha)}\right]^t+P^*+\frac{N}{\alpha} \tag{5.2-4}$$

Where, $A_3=P_0-P^*-\dfrac{N}{\alpha}$;

$$A_4=(P_0-P^*-\frac{N}{\alpha})\frac{\beta_1+\beta_2}{\beta_1-\beta_2} \tag{5.2-5}$$

Case (3). Complex Roots: $(\beta_1+\beta_2)^2-4\alpha\beta_2<0$

$$P_t=r^t\left[A_5\cos(\theta t)+A_6\sin(\theta t)\right]+P^*+\frac{N}{\alpha} \tag{5.2-6}$$

Where, $A_5=P_0-P^*-\dfrac{N}{\alpha}$;

$$A_6=-(P_0-P^*-\frac{N}{\alpha})\left[\frac{\beta_1+\beta_2}{4\alpha\beta_2-(\beta_1+\beta_2)^2}\right]; \tag{5.2-7}$$

$$r^2=|\lambda|^2=\frac{\beta_2}{\alpha-\beta_1};\ r=\sqrt{\frac{\beta_2}{\alpha-\beta_1}} \tag{5.2-8}$$

$$\cos\theta=\frac{\lambda_r}{r}=\frac{\dfrac{\beta_1-\beta_2}{2(\beta_1-\beta)}}{\sqrt{\dfrac{\beta_2}{\alpha-\beta_1}}}=\frac{\beta_2-\beta_1}{2\sqrt{\beta_2(\alpha-\beta_1)}}\text{, so,} \tag{5.2-9}$$

$$\theta=\arccos\left[\frac{\beta_2-\beta_1}{2\sqrt{\beta_2(\alpha-\beta_1)}}\right] \tag{5.2-10}$$

$$\text{Amplitude}=\sqrt{A_5^2+A_6^2}\cdot r^t=\left|P_0-P^*-\frac{N}{\alpha}\right|\cdot\sqrt{\frac{4\alpha\beta_2}{4\alpha\beta_2-(\beta_1+\beta_2)^2}}\cdot\left(\sqrt{\frac{\beta_2}{\alpha-\beta_1}}\right)^t \tag{5.2-11}$$

$$\text{Frequency}=\frac{\theta}{2\pi}=\frac{1}{2\pi}\cdot\arccos\left[\frac{\beta_2-\beta_1}{2\sqrt{\beta_2(\alpha-\beta_1)}}\right] \tag{5.2-12}$$

Appendix 5.2 Rewriting the Features of the Difference Equation

Let $\tilde{\alpha} = \frac{\beta_2}{\alpha - \beta_1}$, $\tilde{\beta} = \frac{\alpha}{\alpha - \beta_1}$, If let N=0, then, all the solutions can be expressed in terms

of $\tilde{\alpha}, \tilde{\beta}$:

$$\lambda_1, \lambda_2 = \frac{1}{2}\left[(\tilde{\alpha} - \tilde{\beta} + 1) \pm \sqrt{(\tilde{\alpha} - \tilde{\beta})^2 - 2(\tilde{\alpha} - \tilde{\beta}) + 1}\right] \tag{5.2-1}$$

$$r = \sqrt{\tilde{\alpha}}$$

$$\text{Amplitude} = \left|P_0 - P^*\right| \cdot \sqrt{\frac{4\alpha\beta_2}{4\alpha\beta_2 - (\beta_1 + \beta_2)^2}} \cdot \left(\sqrt{\frac{\beta_2}{\alpha - \beta_1}}\right)^t$$

$$= \left|P_0 - P^*\right| \cdot \sqrt{\frac{4\tilde{\alpha}\tilde{\beta}}{4\tilde{\alpha}\tilde{\beta} - (\tilde{\alpha} + \tilde{\beta} - 1)^2}} \cdot \left(\sqrt{\tilde{\alpha}}\right)^t \tag{5.2-2}$$

$$\text{Frequency} = \frac{1}{2\pi} \cdot \arccos\left[\frac{\beta_2 - \beta_1}{2\sqrt{\beta_2(\alpha - \beta_1)}}\right] = \frac{1}{2\pi} \cdot \arccos\left[\frac{\beta_2 - \alpha + (\alpha - \beta_1)}{2\sqrt{\beta_2(\alpha - \beta_1)}}\right]$$

$$= \frac{1}{2\pi} \cdot \arccos\left[\frac{\frac{\beta_2}{\alpha - \beta_1} - \frac{\alpha}{\alpha - \beta_1} + 1}{2\sqrt{\frac{\beta_2}{\alpha - \beta_1}}}\right] = \frac{1}{2\pi} \cdot \arccos(\frac{\tilde{\alpha} - \tilde{\beta} + 1}{2\sqrt{\tilde{\alpha}}}) \tag{5.2-3}$$

Appendix 5.3 Rewriting the Solutions

Case (1). Distinct Real Roots: $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 > 0$, i.e. $(1 + \tilde{\alpha} - \tilde{\beta})^2 - 4\tilde{\alpha} > 0$

$$P_t = A_1\lambda_1^t + A_2\lambda_2^t + P^* \tag{5.3-1}$$

Where, $A_1, A_2 = \frac{1}{2}(P_0 - P^*)\left[1 \pm \frac{\tilde{\alpha} + \tilde{\beta} - 1}{(\tilde{\alpha} - \tilde{\beta})^2 + 2(\tilde{\alpha} + \tilde{\beta}) + 1}\right]$

λ_1, λ_2 in terms of $\tilde{\alpha}, \tilde{\beta}$ are in Appendix 5.2.

Case (2). Repeated Real Roots: $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 = 0$, i.e. $(1 + \tilde{\alpha} - \tilde{\beta})^2 - 4\tilde{\alpha} = 0$

$$P_t = (A_3 + A_4 t) + \left[\frac{\tilde{\beta} - \tilde{\alpha} - 1}{(\tilde{\beta} - 2)}\right]^t + P^* \qquad (5.3\text{-}2)$$

Where, $A_3 = P_0 - P^*$

$$A_4 = (P_0 - P^*)\frac{\tilde{\alpha} + \tilde{\beta} - 1}{\tilde{\beta} - \tilde{\alpha} - 1} \qquad (5.3\text{-}3)$$

Case (3). Complex Roots: $(\beta_1 + \beta_2)^2 - 4\alpha\beta_2 < 0$, i.e. $(1 + \tilde{\alpha} - \tilde{\beta})^2 - 4\tilde{\alpha} < 0$

$$P_t = r^t\left[A_5 \cos(\theta t) + A_6 \sin(\theta t)\right] + P^* \qquad (5.3\text{-}4)$$

Where, $A_5 = P_0 - P^*$

$$A_6 = -(P_0 - P^*)\left[\frac{\tilde{\alpha} + \tilde{\beta} - 1}{\sqrt{2(\tilde{\alpha} + \tilde{\beta}) - (\tilde{\alpha} - \tilde{\beta})^2 - 1}}\right] \qquad (5.3\text{-}5)$$

$$r = \sqrt{\tilde{\alpha}} \qquad (5.3\text{-}6)$$

Appendix 5.4 Singapore Government Policy on Property Market since 1960

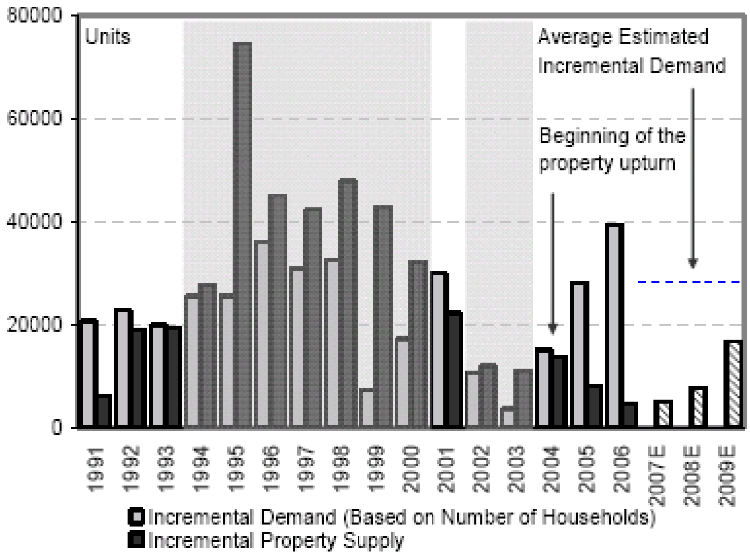
1960 The Housing Development Board (HDB) was established with the objective of providing housing for the population.
1964 The Home Ownership Scheme was introduced. Under this scheme, people are allowed to buy flats from HDB. Previously, only rental was allowed.
1968 The Approved Housing Scheme was introduced. Central Provident Funds (CPF) savings could now be used for purchases of HDB flats in the downpayment as well as monthly mortgage payments.

1971 HDB flats were now allowed to be sold in the open market instead of selling back to HDB.
1973 Under the Housing Property Act, foreigners were restricted from purchasing selected types of properties.
1981 The Approved Housing Property Scheme was introduced. This extended the use of CPF savings to purchases of private housing properties.
1985 An economic recession was underway. A number of market revival measures were introduced to help the property market. The measures included a 30 property tax rebate, a 3-yr deferment on loan repayment for government land sales and a longer project completion period.
1986 More measures were introduced. The property tax rebate was increased to 50 and Permanent Residents (PRs) could use the deposit paid for PR status to finance private housing purchases.
1988 The Differential Pricing Policy Scheme was introduced. Prices of flats in better location were priced at a premium than others.
1989 PRs were now allowed to buy resale HDB flats and HDB owners were now allowed to invest in private properties.
1992 The Design-and-Build Scheme for HDB was introduced to allow more variety in flat design through the use of private companies.
1993 The Mortgage Loan Financing Scheme was revised. Valuation of a resale HDB flat was required. This allowed purchasers to take on
1994 The CPF Housing Grant Scheme, which provided financial assistance to 1st-timer flat buyers, was introduced.
1996 The property boom continued and anti-speculation measures were implemented. The initial downpayment was increased from 10% to 20% and could not be financed by CPF savings. Capital gains from sale of property within 3 years were treated as income and taxed at 100% (if sold within 1 yr), 66% (if sold within 2 yrs) and 33% (if sold within 3 yrs). Sellers, as well as buyers were required to pay stamp duty if sales were made within 3 years.
1997 The time-bar for applying for a HDB flat purchase for the second time was raised from 5 years to 10 years. Criteria for housing loans were also tightened with a maximum of only 2 subsidized loans allowed for HDB flats.
1998 Government Land Sales was suspended.
2000 Government Land Sales was resumed.
2001 URA Reserve List System was introduced. Land sites were put on a reserved list and would go for public tender only if developer put in a bid higher than or equal to the reserve price. Property capital gains tax, introduced in 1996, was removed for property sales contracted on or after October 13, 2001. Also, foreigners could obtain Singapore dollar loans to purchase housing properties.
2002 HDB Build-to-Order Scheme was implemented. Under this scheme, buyers apply for apartments in their preferred location from specific sites launched. Tender for construction will only be called when most of the apartments in a specific contract have been booked.
2003 HDB will no longer provide market rate mortgage loans. HDB flat buyers, who do not qualify for concessionary rate loans (2.6%) (which is pegged at 0.1-pt above the prevailing CPF interest rate) will now have to take loans from commercial banks.
2005 Government announced plans to build 2 integrated resorts.

2005 Property market measures relaxed. Measures include amongst others (1) Property buyers can now borrow up to 90% of property value instead of 80%. (2) Minimum downpayment reduced from 20% to 10%, with cash payments for private housing property now reduced from 10% to 5%. (3) CPF savings can be used for private housing properties with shorter leases compared to previously. (4) Foreigners now need approval only for purchases of landed properties. Purchases of non-condominium developments of less than 6 levels now need no prior approvals. (5) Non-related singles can now use CPF savings to jointly purchase private housing properties instead of only HDB flats.

(***Source***: REDAS, Morgan Stanley Research, 2007)

Appendix 5.5 Singapore Housing Property Demand and Supply Dynamics



(Source: CEIC, Morgan Stanley Research, 2007)

<u>NB</u>. Area shaded in grey were for periods when there is oversupply; incremental demand is calculated based on the increase in the number of households; incremental property supply includes both private housing property and public housing property. Supply data up till 2006 refers to additional supply net of demolishment. Supply data after 2006 refers only to the gross private housing property supply.