Chapter 2

Theories and Literature Reviews

2.1 Economic growth theories

There are basically three economic growth theories reviewed in this part, which are growth theory with exogenous saving rates, growth theory with consumer optimization and the endogenous growth theory.

2.1.1 Growth theory with exogenous saving rates

The Solow (1956) growth model starts from the production function:

$$Y\ (t) = F\ [K\ (t), L\ (t)] \tag{2.1}$$

where *Y (t)* is the flow of output produced at time *t*. *K (t)* is capital at time *t*. *L (t)* is the labor at time *t*.

Assuming there is only a one-sector production technology. The output is a homogeneous good which can be consumed, *C (t)*, or invested, *I (t)*. Investment is used to produce new capital, *K (t)*, or to replace old, depreciated capital.

Imaging that the economy is closed, the households cannot buy foreign goods or assets and cannot export home goods or assets to other countries. All output is used for consumption *C (t)* or gross investment *I (t)*, which can be rewritten as:

$$Y\ (t) = C\ (t) + I\ (t) = C\ (t) + S\ (t). \tag{2.2}$$

Let $s\ (\cdot)$ be the fraction of output that is saved, so the fraction of output which is consumed is $1 - s\ (\cdot)$. To facilitate this analysis, assume that $s\ (\cdot)$ is given exogenously and $0 \leq s\ (\cdot) = s \leq 1$. Thus, the saving can be written as:

$$S\ (t) = s\ Y\ (t) \tag{2.3}$$

By using equation (2.2) and (2.3), the investment can be achieved as

$$I\ (t) = s\ Y\ (t) \tag{2.4}$$

If equation (2.4) is substituted in equation (2.2), the consumption becomes

$$C\ (t) = (1\text{-}s)\ Y\ (t) \tag{2.5}$$

Assume capital is a homogeneous good and depreciates at the constant rate of $\delta > 0$; or in other words, a constant proportion of the capital stock wears out at each point in time and can no longer be used for production. Moreover, assume all units of capital are equally productive, regardless of when they were originally produced.

The net increase in the stock of physical capital at a point in time equals gross investment less depreciation:

$$\dot{K}(t) = I(t) - \delta K(t) = s \cdot F[K(t), L(t)] - \delta K(t) \tag{2.6}$$

where a dot over a variable, denotes differentiation with respect to time, $\dot{K}(t) \equiv \partial K(t)/\partial t$ and $0 \leq s \leq 1$. Equation (2.6) shows the dynamics of $K\ (t)$ for a given labor. Dividing both sides of equation (2.6) by $L\ (t)$, equation (2.7) can be achieved as:

$$\dot{K}(t)/I(t) = s \cdot f(k(t)) - \delta k(t) \tag{2.7}$$

The right-hand side contains per capita variables only, but the left-hand side does not. Thus, it is not an ordinary differential equation that can be easily solved. In order to rewritten it into a differential equation in terms of $k\ (t)$, taking the derivative of $k\ (t) \equiv K\ (t)\ /\ L\ (t)$ with respect to time, the equation (2.8) can be achieved as:

$$\dot{k}(t) \equiv \frac{d(K(t)/L(t))}{dt} = \dot{K}(t)/L(t) - nk(t) \tag{2.8}$$

where $n = \dot{L}(t)/L(t)$. Substituting this result into the expression for $\dot{K}(t)/L(t)$, equation (2.7) can be rewritten as:

$$\dot{k}(t) = s \cdot f(k(t)) - (n + \delta) \cdot k(t) \tag{2.9}$$

In the steady state, equation (2.9) can be written as

$$s\, f(k^*) = (n + \delta)\, k^* \tag{2.10}$$

Since k is constant in the steady state, y and c are also constant at the values $y^* = f(k^*)$ and $c^* = (1 - s) \cdot f(k^*)$, respectively. Therefore, it can be concluded that, in the neoclassical model, the per capita variables k, y, and c do not grow in the steady state. The constancy of the per capita magnitudes indicates that the levels of variables, K, Y, and C, grow in the steady state at the rate of population growth, n.

2.1.2 Growth theory with consumer optimization

Ramsey (1928) proposed a model that can answer the question of how much a nation should save and invest. His model is now the prototype for studying the optimal intertemporal allocation of resource.

In his model, the population denoted by N_t grows at a positive rate of n; it can be thought of as a family, or many identical families that growing over time.

The capital and labor are used to produce the output. There is no productivity growth. The output is either consumed or invested, that is, added to the capital stock.

$$Y(t) = F[K(t), N(t)] = C(t) + dK(t)/dt \tag{2.11}$$

For simplicity, assume that the capital is not depreciated. There is constant return to scale; or in other words, the production function is homogenous of degree one.

The equation (2.11) can be written in an intensive form by divide it with *N (t)* as:

$$y(t) = f[k(t)] = c(t) + dk(t)/dt + nk(t) \tag{2.12}$$

On the other hand, the preferences of the family for consumption over time are represented by the utility integral:

$$U(t) = \int_0^\infty u[c(t)] \cdot e^{-\rho t} e^{nt} dt \tag{2.13}$$

where ρ is the rate of time preference, or the subjective discount rate, which is assumed to be strictly positive. n is the population growth rate.

The family's welfare at time t is denoted by $U(t)$, which is the discounted sum of instantaneous utilities $U(c(t))$.

The function $u(\bullet)$ is known as the instantaneous utility function, or as "felicity"; $u(\bullet)$ is a nonnegative and concave increasing function of the per capital consumption of family members.

Suppose that a central planner wants to maximize family welfare at time $t = 0$. The only choice that the central planner has to be made at each moment of time is how much the representative family should consume and how much it should add to the capital stock to provide consumption in the next period.

The planer has to find the solution to the following problem:

$$\max \; U(0) = \int_0^\infty u[c(t)] \cdot e^{-\rho t} e^{nt} dt \tag{2.14}$$

$$\text{subject to } y(t) = f[k(t)] = c(t) + dk(t)/dt + nk(t) \tag{2.15}$$

The optimal solution is achieved by setting up the present value Hamiltonian function as:

$$H(t) = u[c(t)] \cdot e^{-\rho t} e^{nt} + \mu(t)\{f[k(t)] - nk(t) - c(t)\} \tag{2.16}$$

The variable μ is called the costate variable associated with the state variable *k*; equivalently it is the multiplier on the right hand of constraint equation (2.15).

The first order conditions are:

$$u'[c(t)] = \lambda(t) \tag{2.17}$$

$$\lambda(t)\{\rho + n - f'[k(t)]\} = \dot{\lambda}(t) \tag{2.18}$$

Equation (2.17) and (2.18) be consolidated to remove the costate variable λ *(t)*, yielding

$$\frac{du'[c(t)]}{dt} = u'[c(t)]\{\rho + n - f'[k(t)]\}$$

$$\frac{du'[c(t)]/dt}{u'[c(t)]} = \{\rho + n - f'[k(t)]\} \tag{2.19}$$

From equation (2.19), multiplying $\frac{dc(t)}{dc(t)}$ on the left hand side, we get

$$\frac{dc(t)/dt}{c(t)} = \frac{u'[c(t)]}{c(t)u''[c(t)]}\{\rho + n - f'[k(t)]\} \tag{2.20}$$

Taking the limit of that expression as *s* converges to *t* gives $\sigma = -\frac{u'[c(t)]}{c(t)u''[c(t)]}$, so that $\sigma[c(t)]$ is the inverse of the negative of the elasticity of marginal utility.

Using the definition of σ, equation (2.20) can be written as:

$$\frac{dc(t)/dt}{c(t)} = \sigma[c(t)]\{f'[k(t)] - \rho - n\} \tag{2.21}$$

in steady state, equation (2.21) becomes

$$\frac{dc(t)/dt}{c(t)} = 0 = \sigma[c(t)]\{f'[k(t)] - \rho - n\} \tag{2.22}$$

Equation (2.22) is expressed as the modified golden rule. It implies that the capital stock is reduced below the golden rule level by an amount depends on the rate of time preference, ρ. It also indicates that the per capital consumption *c (t)* increases, remains constant or decrease depends on whether the marginal product of capital is greater, equal to or less than the rate of time preference ρ.

2.1.3 Endogenous growth theory

Barro, R.J. (2004) mentioned that, in the mid-1980s, it became increasingly clear that the standard neoclassical growth model can not satisfactorily explore the determinants of long-run growth. The basic reason is the existence of diminishing returns to capital. One method which can solve this problem was to broaden the concept of capital, such as including human components, and then assumed that diminishing returns did not apply to this broader category of capital. Another view was that, the only way which an economy could escape from diminishing returns in the long run was the technological progress in the form of new ideas. Hence, it became a priority to go beyond the treatment of taking technological progress as exogenous variable and, instead, it will explain this progress within the model of growth. However, endogenous methods to technological change met basic problems within the neoclassical model. The fundamental reason was the nonrival nature of the ideas that underlie technology.

Remember that a key property of the state of technology, *T (t)*, is that it is a nonrival input during the production process. Hence, the replication argument which we used in the past to justify the assumption of constant returns to capital scale suggests that the correct measure of the scale is the two rival inputs, that is, capital and labor. Hence, the concept we used in constant returns to scale is homogeneity of degree one in capital and labor:

$$F(\lambda K(t), \lambda L(t)) = \lambda \cdot F(K(t), L(t)) \tag{2.23}$$

Recall that Euler's theorem tells us that a function which is homogeneous of degree one can be decomposed as

$$F(K(t), L(t),) = F_K \cdot K(t) + F_L \cdot L(t) \tag{2.24}$$

Moreover, perfectly competitive firms that take the input prices, R and w, as given by equating the marginal products to the respective input prices, that is, $F_K = R$ and $F_L = w$. It follows that the factor payments exhaust the output, so that each firm earns a zero profit at every point in time.

These conceptual difficulties inspired researchers to introduce some perspectives of imperfect competition to construct satisfactory models in which the level of the technology can be improved by some purposeful activities, such as R&D expenditures. This may allow an escape from diminishing returns at the aggregate level for endogenous technological progress and, hence, endogenous growth.

The key characteristic of this kind of endogenous growth models is the absence of diminishing returns to capital. The simplest version of a production function which escapes form diminishing returns is the AK function:

$$Y(t) = AK(t) \tag{2.25}$$

where A is a positive constant that reflects the level of the technology. It is unrealistic to achieve a global absence of diminishing returns, but the idea becomes more plausible if we think of capital in a broad sense which including the human capital. Output per capita is $y = A\ k(t)$, and the average and marginal products of capital are constant at the level that $A > 0$.

Substitute $f(k(t)) / k(t) = A$ in equation (2.9), we get

$$\dot{k}(t)/k(t) = sA - (n+\delta) \qquad (2.26)$$

Since $y = A\ k\ (t)$, $\dot{y}(t)\ /\ y\ (t) = \dot{k}(t)\ /\ k\ (t)$ at every point in time. In addition, since $c\ (t) = (1-s) \cdot y\ (t)$, $\dot{c}\ (t)\ /c\ (t) = \dot{k}(t)\ /\ k\ (t)$ also applies. Hence, all the per capita variables in the model always grow at the same, constant rate, given by

$$\gamma^* = s\ A - (n + \delta) \qquad (2.27)$$

The AK model enables an endogenous growth by avoiding diminishing returns to capital in the long run. This particular production function also implies, that the average and marginal products of capital are always constant and, thus, growth rates do not exhibit the property of convergence. It is possible to retain the characteristic of constant returns to capital in the long run, while restoring the convergence property, which is an idea brought out by Jones and Manuelli (1990).

2.2 Hedonic house price theory

The hedonic price theory is also known as a hedonic model or utility assessment method. A hedonic model shows the relation among prices of different varieties of a product, for example, personal computers and the quantities of characteristics in them. A theory of hedonic prices is formulated to make the quality evaluation and location decisions both for consumers and producers according to the characteristics of different goods, such as automobiles, computers, properties, and etc.

Based on Lancaster (1966)'s consumer theory, the hedonic price model firstly was build for the government to assess the compute prices. Rosen (1974) later extended this model to the residential market. Thus, this kind of residential hedonic analysis has become widely used as an assessment tool for real estate market. It regards that the real estate market is composed of different characteristics and the real estate price is determined by the utility arisen from its characteristics.

The hedonic house price procedure aims to qualify and assess the effort of various housing and neighborhood characteristics on house prices. Empirically, this method uses house characteristics and the regression analysis to explain variation in marketing values. A hedonic equation for single-family homes relates some marketing value estimates, such as an owner's estimate, a tax assessor's estimate, a real estate appraiser's estimate, or, if the house was recently sold, the transaction prices, to the house's characteristics which including the lot size, dwelling age, neighborhood amenities, public services, etc.

Goodman A.C. and Thibodeau T.G. (1995) introduced a hedonic equation for owner-occupied homes which related an estimate of the real estate's market value to the various characteristics that determine its value. Those housing characteristics in their studies can be loosely divided into five classes: (1) characteristics of the lot, (2) characteristics of the improvement, (3) neighborhood variables, (4) proximity variables, and (5) the period when the property information are collected. The general form for a hedonic house price equation is shown as:

$$V = f(L, S, N, P, t), \tag{2.28}$$

where *V* is the estimated market values of the house, or the sales prices;

L denotes a category of variables describing the lot characteristics, such as lot size, shape, site improvements, etc.;

S denotes a class of variables describing structural characteristics, for example, the square feet of living space, dwelling age, types of equipment and fuels used to provide services, etc.;

N denotes a group of neighborhood amenities, such as the percentage of improved land area in the neighborhood allocated to owner-occupied homes, percentage nonresidential, percentage undeveloped, employment density, public school achievement scores, police and fire department response times, crime rates, etc.;

P denotes a class of proximity variables, such as the distance to the central business district, various nonconforming land uses that may produce externalities, neighborhood recreation facilities, schools, shopping, hospitals, public transportation, major subways, etc.;

t denotes the period when the house data was collected.

2.3 Econometric theories

2.3.1 Panel unit root test

There are six methods for panel data unit root test, which are: Levin et al. (2002), or LLC, Breitung (2000), Im et al. (2003), or IPS, Fisher-type tests using ADF (Maddala and Wu, 1999), Fisher-type tests using PP tests (Choi, 2001), and Hadri (2000) to check for the presence of stationarity around a deterministic trend or mean with a shift against a unit root. The properties of panel-based unit root tests under the assumption that the data is independent and identically distributed (i.i.d.) across individuals. Two panel unit root tests: LLC and IPS, are performed to check for the presence of stationary in this study.

In general, the type of panel unit root tests is based upon the following regression which include lagged dependent variable to remove autocorrelation;

$$\Delta y_{i,t} = \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \phi_{iL} \Delta y_{i,t-L} + z'_{i,t}\gamma + u_{i,t} \tag{2.29}$$

where $i=1,2,\ldots,N$ is the provinces, $t=1,2,\ldots,T$ is time series observation are available. $y_{i,t}$ is the dependent variable for i individuals at time t. ρ_i is the coefficient of one period lagged variable. ϕ_{iL} and γ are $k_1 \times 1$ and $k_2 \times 1$ vectors of exogenous variables. $z_{i,t}$ is the deterministic components and $u_{i,t}$ is iid$(0,\sigma_i^2)$. $z_{i,t}$ could be zero, one, the fixed effects (μ_i) or fixed effect as well as a time trend (t).

1) Levin, Lin and Chu (LLC) Test

In the Levin, Lin and Chu (LLC) (2002) tests, one assumes homogeneous autoregressive coefficients between individuals, i.e. $\rho_i = \rho \; \forall i$ and tests the null hypothesis $H_o : \rho_i = \rho = 0$ against the alternative $H_a : \rho_i = \rho < 0$.

The structure of the LLC analysis may be specified as follows:

$$\Delta y_{i,t} = \rho y_{i,t-1} + \alpha_{0i} + \alpha_{1i}t + u_{i,t}, \quad i = 1,2,...,N, \quad t = 1,2,...,T \qquad (2.30)$$

It can be seen that a time trend $\alpha_{1i}t$ as well as individual effects (α_i) are incorporated in this structure. Note that the deterministic components are an important source of heterogeneity in this model since the coefficient of the lagged dependent variable, ρ, is restricted to be homogeneous across all units in the panel.

$u_{i,t}$ is assumed to be independently distributed across individuals and follow a stationary invertible ARMA process for each individual:

$$u_{i,t} = \sum_{j=1}^{\infty} \theta_{ij} u_{i,t-j} + \varepsilon_{i,t} \qquad (2.31)$$

and the finite-moment conditions are assumed to assure the weak convergence in Phillips (1987) and Phillips-Perron's (Phillips and Perron, 1988) unit root tests.

LLC show that under the null, a modified t-statistic for the resulting ρ is asymptotically normally distributed

$$t_{\rho}^{*} = \frac{t_{\rho=0} - N\widetilde{T}\hat{S}_N \hat{\sigma}_{\tilde{\varepsilon}}^{-2} RSE(\hat{\rho}) \mu_{m\widetilde{T}}^{*}}{\sigma_{m\widetilde{T}}^{*}} \rightarrow N(0,1) \qquad (2.32)$$

being $\mu_{\widetilde{T}}^{*}$ and $\sigma_{\widetilde{T}}^{*}$ the mean and the standard deviation adjustment terms which are obtained from Monte Carlo simulation and tabulated in Levin and Lin's paper (1992), $\hat{S}_N = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\sigma}_{yi}}{\hat{\sigma}_{ei}}$ is defined as the mean of the ratios of the long-run standard deviation to the innovation standard deviation for each individual where $\hat{\sigma}_{yi}^{2}$ denotes a kernel estimator of the long-run variance for the individual i and $\widetilde{T} = T - \left(\sum_i p_i / N\right) - 1$. The LLC method requires a specification of the number of lags used in each cross-section ADF regression, p_i, as well as kernel choices used in the computation of $\hat{S}_N$.

However, the LLC test has some limitations about the test depends crucially upon the independence assumption across individuals and hence not applicable if cross sectional correlation is presents.

2) Im, Pesaran and Shin (2003) Test

Im et al. (2003) extended the Levin and Lin framework to allow for heterogeneity in the value of the autoregressive coefficient under the alternative hypothesis. Im, Pesaran, and Shin begin by specifying a separate ADF regression for each cross section:

$$\Delta y_{i,t} = \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \phi_{iL} \Delta y_{i,t-L} + z'_{i,t}\gamma + u_{i,t} \qquad (2.33)$$

The null hypothesis can be written as $H_0 = \rho_i = 0 \; \forall i$. While the alternative hypothesis is given by:

$$H_a : \begin{cases} \rho_i = 0, \; for \; i = 1,2,\ldots,N_1 \\ \rho_i < 0, \; for \; i = N_1,\ldots,N \end{cases} \qquad (2.34)$$

that allows for some (but not all) of individual series to have unit roots. The lag length is fixed across cross-sections.

IPS compute separate unit root tests for the N cross-section units and define their t-bar statistic as a simple average of the individual ADF statistics, t_{iT}, for the null as:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_{iT} \qquad (2.35)$$

IPS assume that t_{iT} are *i.i.d.* and have finite mean and variance. Therefore, by Lindeberg-Levy central limit theorem, the standardized t-bar statistic converges to a standard normal variate as $N \to \infty$ under the null hypothesis.

2.3.2 Panel cointegration test

There are three methods for panel cointergration tests. The Pedroni and Fisher tests are based on the Engle-Granger method. The third is Kao test, based on combined Johansen. In this study, Pedroni (2004) test is used to test the cointegration relationship.

Pedroni (1999, 2004) proposes a residual-based test for the null of cointegration for dynamic panels with multiple regressors. The test allows for individual heterogeneous fixed effects and no exogeneity requirements are imposed on the regressors of the cointegrating regressions.

The residuals estimation from static cointegrating long-run relation for a time series panel of observables y_{it} and x_{it}:

$$y_{i,t} = \alpha_{1i} + \beta_{1l} x_{i,t} + \mu_{i,t} \qquad (2.36)$$

$$x_{i,t} = \alpha_{2i} + \beta_{2l} y_{i,t} + \nu_{i,t} \qquad (2.37)$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$.

The variables $y_{i,t}$ and $x_{i,t}$ are assumed to be *I(1)*, for each member *i* of the panel. Under the null of no cointegration, the residual $\mu_{i,t}$ and $\nu_{i,t}$ will also be *I(1)*. α_i are scalar denoting fixed effects parameters and β_l are the cointegration slopes which permitted to vary across individuals, so that considerable heterogeneity is allowed by this specification.

Pedroni (2004) provided seven statistics for the test of the null hypothesis of no co-integration in heterogeneous panels. Pedroni (2004) tests can be classified into two categories. One group of such tests are termed "*within dimension*" (panel tests) and the other "*between dimension*" (group tests). The "*within dimension*" tests pool the data across the ''*within dimension*,'' thereby taking into account common time factors and allowing for heterogeneity across members. The ''*between dimension*'' tests allow for heterogeneity of parameters across members, and are called ''*group mean cointegration statistics*''.

In fact, even if both sets of test verify the null hypothesis of no cointegration: $H_0 : \rho_i = 1 \quad \forall i,$ where ρ_i is the autoregressive coefficient of estimated residuals under the alternative hypothesis ($\hat{e}_{it} = \rho_i \hat{e}_{it-1} + u_{it}$), alternative hypothesis specification is different:

The panel cointegration statistics impose a common coefficient under the alternative hypothesis which results:

$$H_a^w : \rho_i = \rho < 1 \quad \forall i, \tag{2.38}$$

The panel group mean cointegration statistics allow for heterogeneous coefficients under the alternative hypothesis and it results:

$$H_a^b : \rho_i < 1 \quad \forall i, \tag{2.39}$$

Seven of Pedroni's tests are based upon the estimated residuals $\hat{e}_{it}$ from the long-run model and test statistics that we employ are as follows:

Within dimension (panel tests):

(a) Panel v-statistic

$$Z_v = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1} \tag{2.40}$$

(b) Panel ρ-statistics.

$$Z_p = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_t - \hat{\lambda}_i \right) \tag{2.41}$$

(c) Panel PP-statistic.

$$Z_{pp} = \left(\hat{\sigma}^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_t - \hat{\lambda}_i \right) \tag{2.42}$$

(d) Panel ADF-statistic.

$$Z_t = \left(\hat{S}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}^{*2}_{i,t-1} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \left(\hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}^{*} \right) \tag{2.43}$$

Between dimension (group tests):

(e) Group ρ -statistics.

$$\tilde{Z}_\rho = \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right]^{-1} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{2.44}$$

(f) Group PP-statistic.

$$\tilde{Z}_{pp} = \sum_{i=1}^{N} \left[\hat{\sigma}^2 \sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right]^{-1/2} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{2.45}$$

(g) Group ADF -statistic.

$$\tilde{Z}_t = \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \hat{S}^{*2} \hat{e}_{i,t-1}^{*2} \right]^{-1} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}^{*} \right) \tag{2.46}$$

where $\hat{\sigma}^2$ is the pooled long-run variance for non parametric model given as $1/N \sum_{i=1}^{N} \hat{L}_{11} \hat{\sigma}_i^2$ and $\hat{\lambda}_i = 1/2 \left(\hat{\sigma}_i^2 - \hat{S}_i^2 \right)$, where $\hat{L}_i$ is used to adjust for autocorrelation in panel parameter model, $\hat{\sigma}_i^2$ and $\hat{S}_i^2$ are the long-run and contemporaneous variances for individual *i*, and $\hat{S}_i^2$ is obtained from individual ADF-test of $e_{i,t} = \rho_i e_{i,t-1} + v_{i,t}$. $\hat{S}_i^{*2}$ is the contemporaneous variances from the parametric model, $\hat{e}_{i,t}$ is the estimated residual from the parametric cointegration ,while $\hat{e}^*_{i,t}$ is the estimated residual from parametric model. $\hat{L}_{11i}$ is the estimated long-run covariance matrix for $\Delta \hat{e}_{i,t}$ and L_i is the *i*th component of low triangular Cholesky decomposition of matrix Ω_i for $\Delta \hat{e}_{i,t}$ with the appropriate lag length determined by the New-West method.

It is straightforward to observe that the first category of four statistics includes a type of non-parametric variance ratio statistic, a panel version of a non-parametric Phillips and Perron (1988) ρ-statistic, a non-parametric form of the average of the Phillips and Perron t-statistic and an ADF type t-statistic.

The second category of panel cointegration statistics is based on a group mean approach and includes a Phillips and Perron type ρ-statistic, a Phillips and Perron type t-statistic and an ADF type t-statistic. The comparative advantage of each of these statistics will depend on the underlying data-generating process.

The statistics can be compared to appropriate critical values; if critical values are exceeded then the null hypothesis of no cointegration is rejected, implying that a long-run relationship between the variables does exist.

Pedroni (1997) simulations shows that, when $T > 100$, statistics have the same power. For little samples ($T < 20$), the most powerful test is the ADF test based on the between dimension (group t-statistic).

2.3.3 Error-correction models and Granger causality test

In the case of two variables *X* and *Y*, the Granger causality approach that developed by Granger C.W.J. (1969) is different from the common use of the term since it measures precedence and information provided by *X* in explaining current value of *Y*. *Y* is said to be granger caused by *X* if *X* helps in the prediction of *Y* or equivalently lagged values of *X* are statistically significantly.

Granger (1969) shows that the traditional Granger causality test is based on a vector autoregression model (VAR) as:

$$y_{i,t} = \alpha_{0} + \alpha_1 y_{i,t-1} + \ldots + \alpha_l y_{i,t-l} + \beta_1 x_{i,t-1} + \ldots + \beta_l x_{i,t-l} + \varsigma_{i,t} \quad (2.47)$$

$$x_{i,t} = \alpha_{0} + \alpha_1 x_{i,t-1} + \ldots + \alpha_l x_{i,t-l} + \beta_1 y_{i,t-1} + \ldots + \beta_l y_{i,t-l} + \xi_{i,t} \quad (2.48)$$

Granger (1988) pointed out that if there is a cointegrating vector among variables, there must be at least one unidirectional Granger-causality among these variables. In addition, when the series are cointegrated at *I(1)*, the Granger causality test should be carried out in the framework of ECM instead of a common VAR estimation.

Thus, the VAR equations (2.47) and (2.48) can be written as the error correction models (2.49) and (2.50) as:

$$\Delta y_{i,t} = \alpha_{1j} + \sum_{k=1}^{m} \alpha_{1k} \Delta y_{i,t-k} + \sum_{=1}^{n} \beta_{1l} \Delta x_{i,t-l} + \lambda_{1i} ECT + \varsigma_{i,t} \qquad (2.49)$$

$$\Delta x_{i,t} = \alpha_{2j} + \sum_{k=1}^{p} \alpha_{2k} \Delta x_{i,t-k} + \sum_{l=1}^{q} \beta_{2l} \Delta y_{i,t-l} + \lambda_{2i} ECT + \xi_{i,t} \qquad (2.50)$$

Equation (2.49) shows that the short-run undulation of dependent variable $\Delta y_{i,t}$ is affected by both the short-run independent variable and the ECT, or the long-run equilibrium error. The ECT in this equation is the one period lagged residual form the cointegration function (2.36). If the null hypothesis of $\lambda_{1i} = 0$ is rejected, the long-run equilibrium is reliable. If the null hypothesis of $\beta_{1l} = 0$ is rejected, there is a short-run causality relationship from $x_{i,t}$ to $y_{i,t}$.

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2.4 Literature reviews

2.4.1 General literature reviews

Real estate in many foreign countries is a mature industry. People already have a clear understanding about the status and role of the real estate sector. From the abroad literature, most of economists studied the relationship between national economy and real estate prices by empirical studies, which focus primarily on the equilibrium theory. Based on the traditional regression analysis model, they widely used the independent linear systems, econometric models, and technical economic evaluation models for the data analysis.

The earlier studies, which analyzed the effect of macroeconomic aggregates, such as inflation, economic growth, GDP, unemployment, and other variables, on the housing sector, considered macroeconomic variables as exogenous. Among relevant studies, Clapp and Giaccotto (1994) used simple single regression analysis to show that the macro-economic conditions had a good ability to predict changes on real estate prices. Englund and Ioannides (1997) compared the dynamics of house prices in 15 countries, and discovered that lagged GDP growths exhibited significant predictive power over house prices.

Ouigley (1999) applied a supply-demand model to study the linkages between economic fundamentals and property prices by using yearly data of 41 metropolitan areas in U.S. from 1986 to1994. The result indicated that the U.S. economic fundamentals were possible solutions to the changes in real estate prices.

Iacoviello (2003), in his study of relationship between consumption, house prices, and collateral constraints, found a direct effect of house prices on consumption by using the Euler equation for consumption. Then, according to Coulson and Kim's study (2000), consumption formed a large part of GDP. Therefore, it was reasonable to expect that house prices lead the GDP.

Miki Seko (2003) employed the SVAR model to show that house prices and economic fundamentals in Japan have a relatively strong correlation. It could predict the real estate market changes. Chirinko, DeHaant and Sterken (2004) used a SVAR model to study the relationship between real estate prices, consumptions and outputs in 13 developed countries. The results showed that for a country, real estate prices had bigger effects on the consumptions and outputs than stocks. When there was a 1% increase in the real estate price, there would be a 0.75% increase in consumption. When the real estate price increased 1.5%, the GDP would rise up 0.4%.

Shiller's research (2006) showed that there was no significant effect of house prices on GDP growths, since booming price periods were usually followed by sharp price depreciations. In the United States and other countries there was no long-term upward trend in real estate prices.

Peng, Tam and Yiu (2008) found a two-way linkage between house prices and economic growths. The research showed that bank credit expansion did not play an “accelerating” role in house price inflations. Moreover, house price growths in coastal areas might be deviated from economic fundamentals.

Miller, Liang Peng and Sklarz (2009) studied the effect of house prices on local Gross Metropolitan Products (GMP) from the perspectives of wealth and collateral effects on house prices. They used the quarterly data of all 379 metropolitan statistic areas (MSAs) in the U.S., from the first quarter of 1980 to the second quarter of 2008. They found that house price changes had significant effects on GMP growths, and the collateral effect was about three times stronger than the wealth effect. Second, the persistent component of predictable changes had a stronger collateral effect than the novel component. Third, when households were more financially constrained, the collateral effect was stronger, while the wealth effect was weaker, and the total effect remained unchanged. The study also showed that the effects lasted for eight quarters, and peaked on the fourth quarter after house price changes take place.

Adams and Fuss (2010) examined the impact of macro economy on house prices by using a panel data of 15 countries over a period of more than 30 years to allow the robust estimation of long-term macroeconomic impact. They concluded that one percent increase in economic activity raised the demand for houses and house prices over the long term by 0.6 percent.

Meidani, Zabihi, and Ashena (2011) investigated the causality between house prices, economic growths, and inflations in Iran from the first quarter of 1990 to the third quarter of 2008 using Toda and Yamamoto approach. The results showed that there was a significant multidirectional linkage between house prices and macroeconomic factors. The causality tests confirmed that economic growths and inflations Granger caused house prices, and feedback effects were observed for house prices and economic growths. This paper found no evidence of Granger causality of real house price changes to inflations.

Simo-Kengne, Bittencourt and Gupta (2011) did an empirical research about the effect of house price changes on economic growths in South Africa. The economic impact of house prices was estimated using a panel data set that covers all nine provinces in South Africa from 1996 to 2010. The authors found that when heterogeneity, endogeneity and spatial dependence were controlled, house price changes exhibited a significant effect on the regional economic growths in South Africa. The paper then introduced a Seemingly Unrelated Regression (SUR) specification and showed that spatial effects were highly important for South African house market. Moreover, the estimation results suggested that the wealth effect was important at the aggregated level which contrasted the results of the collateral effect that found at the regional level.

2.4.2 Chinese literature reviews

China's real estate market developed later than foreign countries. Along with China's rapid economic growths, the real estate industry was also on a good prospect. Housing problem was not only related to the urban development and financial security theories, but also related to the living cost of ordinary people. The importance and sensitivity of the house price had attracted a large number of scholars' attentions. Most of the studies on the relationship between real estate prices and the national economy were theoretical researches. The empirical researches were rare.

Given the important effects of economic fundamentals on real estate prices, applying the appropriate data and model to study the relationship between them had always been a hot issue. Songcheng Sheng and Bin Liu (2001) conducted an in-depth comparative analysis of real estate market in China, Japan and America. This study revealed that demand was the determinant factor which affected house price fluctuations. It showed that there was a bidirectional relationship between economic developments and real estate prices. Real estate prices showed an increase trend along with a prospective economy.

Chau and Lam (2001) examined the speculations and property prices in Hong Kong. The empirical results revealed that nominal GDP was a leading indicator of house prices. Nominal GDP was used in the model to capture the effects of inflations and economic growths, while house prices were derived from the Rating and Valuation Department (RVD). This study suggested that Hong Kong's economic performance was dependent on that of property market, which meant that property prices lead the economic growths and drove inflations.

Hui and Yiu (2003) used Granger Causality Test to do an empirical study on the relationship between market fundamentals and residential real estate prices in Hong Kong. This study showed that the residential prices lead GDP from the first quarter of 1984 to the fourth quarter of 2000, but not the opposite. The following reason was suggested by Hui and Yiu: GDP represented an overall change of the economy, and was regarded as one of the market fundamentals that affected the demand for private residential real estate. Moreover, GDP was affected by some market fundamentals. Since both real estate prices and GDP were expectation driven, both of them lagged behind the release of information for market fundamentals.

Yue Shen and Hongyu Liu (2004) used the panel data and a simple regression method to study the relationship between house prices and economic fundamentals in 14 cities, from 1995 to 2002. Their results showed that the explanatory economic fundamentals model for house prices had different characteristics for different cities.

Chui and Chau (2005) examined the lead-lag relationships between real estate prices, real estate investments, and economic growths in Hong Kong. The results suggested that there was no relationship between GDP and real estate investments. This contradicted the results of similar previous studies in other economies.

Cailou Jiang, Kangning Xu, and Yongfu Li (2007) used the monthly data of Shanghai housing market from March, 2003 to August, 2006, cointegration and Granger causality test to examine the fluctuations of house prices. The results showed that the level of macro-economic developments and real estate investments were the main factors which affected the real estate price fluctuations. The per capita disposable income and vacancy had little influents on real estate prices.

Yue Shen and Hongyu Liu (2004) calculated the value of house, urban land and non-urban land of China between 1990 and 2001. The research figured out the ratio of real estate assets value and the national wealth in China and compared this index with related indexes of Japan, USA and UK. The results showed that the value of real estate assets and national wealth will increase along with the economic growths.

Zhonghua Huang, Xuejun Du, and Cifang Wu (2008) analyzed the interaction between house prices and macro economy, based on econometric method. The results showed that house prices and macro economy in China were stable in a long term and unbalanced in a short run. There was a bilateral causality between house prices and economic growths in China, while the relationship between house prices and interest rates was insignificant. The historical house prices and economic growths were the main factors affecting house prices. The historical GDP and house prices had an important influence on economic growths.

Chengshi Tian, Hui Li (2008) analyzed the dynamic relations of China's real estate prices and main macroeconomic factors in recent years using cointegration and error correction model. The results showed that real estate prices should be in coordinating with the social economic level in the long term. If the tendency of real estate prices had departed from the macroeconomics supporting, then the market might have some risks.

Huanru Song and Jian Wei (2009) used the quarterly data from the first quarter of 2001 to the fourth quarter of 2008, and a cointergration test to study the relationship between real estate prices and macro fundamentals, such as GDP, interest rates, inflations, and other variables. The empirical results showed that real estate prices had a stable relationship with macro fundamentals in the long run. GDP and CPI Granger caused house prices.

Yu Kong (2009) used simultaneous equations model, based on national and provincial panel data, to study the relationship between house prices, bank lending and economic growths. The results showed that there was a close relationship among house prices, bank lending and economic growths. But the empirical research of the relationship in each region of China was different. The results revealed that bank lending was the most efficient factor which pulled the regional house prices. And economic growths were the common factors that promoted the expansion of bank lending in each region. The analysis also suggested that house prices and bank lending expansion had accelerated the boom of economy.

The summary of literature reviews are shown as following table 2.1 and 2.2.

Table 2.1 Summary of general literature reviews

Authors	Methodology / variables	Results	Symbol
Clapp and Giaccotto (1994)	a simple single regression	Macro-economic conditions had a good ability to predict changes on real estate prices.	R
Englund and Ioannides (1997)	house prices and economic growths	Lagged GDP exhibited significant predictive powers over house prices.	√
Ouigley (1999)	a supply-demand model	U.S. economic fundamentals were possible solutions to changes in real estate prices.	R
Iacoviello (2003)	consumptions, house prices, and collateral constraints	House prices have a direct effect on consumptions. It was reasonable to expect that house prices will have a leading relationship to GDP.	√
Miki Seko (2003)	a SVAR model	House prices and economic fundamentals in Japan have a relatively strong correlation.	R
Chirinko, DeHaant and Sterken (2004)	a SVAR model	When the real estate price increased 1.5%, the GDP would rise up 0.4%.	√
Shiller (2006)	house prices and economic growths	There is no significant effect of house prices on GDP growths.	×
Peng, Tam and Yiu (2008)	house prices, GDP and bank credits	A two-way linkage between house prices and GDP growths.	√
Miller, Liang Peng and Sklarz (2009)	common correlated effects estimators	House prices changes had significant effects on Gross Metropolitan Product growths.	√
Adams and Fuss (2010)	panel data method	One percent increase in economic activity raised the demand for houses and house prices over the long term by 0.6 percent.	R
Meidani, Zabihi, and Ashena (2011)	Toda and Yamamoto approach	GDP and CPI Granger caused house prices.	√
Simo-Kengne et al. (2011)	a Seemingly unrelated regression	HP changes exhibited a significant effect on regional economic growths in South Africa.	√

Note: 1. The symbol "√" indicates the results that there is a one-way or two-way relationship between house prices and economic growths.
2. The symbol "×" indicates the results that there is no relationship between house prices and economic growths.
3. The symbol "R" is the related researches relevant to the relationship between house prices and economic growths

Table 2.2 Summary of Chinese literature reviews

Authors	Methodology / variables	Results	Symbol
Songcheng Sheng and Bin Liu (2001)	a comparative analysis	A bidirectional relationship between economic developments and real estate prices.	√
Chau and Lam (2001)	speculations and property prices	Nominal GDP was a leading indicator of house prices.	√
Hui and Yiu (2003)	Granger Causality Test	Residential prices lead GDP. GDP does not lead residential prices.	√
Yue Shen and Hongyu Liu (2004)	panel data and a simple regression method	The explanatory economic fundamentals model for house prices had different characteristics for different cities.	R
Chui and Chau (2005)	HP, investments and GDP	There was no relationship between GDP and real estate investments.	×
Cailou Jiang, Kangning Xu, and Yongfu Li (2007)	cointegration and Granger causality	The level of macro-economic developments and real estate investments were the main factors which affected the real estate price fluctuations.	R
Yue Shen and Hongyu Liu (2004)	value of house, urban land and non-urban land	The value of real estate assets and national wealth will increase along with economic growths.	R
Zhonghua Huang, et al. (2008)	Vector autoregression	House prices and macro economy was stable in a long term and unbalanced in the short run.	√
Chengshi Tian, Hui Li (2008)	cointegration and error correction model	Real estate prices should be in coordinating with the social economic level in the long term.	R
Huanru Song and Jian Wei (20090	cointergration test	GDP and CPI Granger caused house prices.	√
Yu Kong (2009)	the simultaneous equations model	A close relationship between house prices, bank lending and economic growths.	√

Note: 1. The symbol "√" indicates the results that there is a one-way or two-way relationship between house prices and economic growths.

2. The symbol "×" indicates the results that there is no relationship between house prices and economic growths.

3. The symbol "R" is the related researches relevant to the relationship between house prices and economic growths