LOCAL HOUSING SUBMARKET STRUCTURE AND REGIONAL HOUSEHOLD HOUSING CHOICE BEHAVIOUR

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ABSTRACT

As home ownership in the UK housing market has become mature, economic and econometric analyses of urban and regional owner-occupier housing markets have become a long-standing concern of housing economists.

This thesis defines a nested local housing submarket structure.The dynamic stock flow model with trade friction is revised and applied to analysing the local owner occupier housing submarket operational process. The short run and long run equilibrium and disequilibrium nature of a local owner occupier housing submarket system are divulged. This model explores the submarket house price determinants and the role of housing submarket trade friction in submarket house price formation. The computer simulation reveals the relationship between the housing submarket structure and the system stability. The role of household housing choice behaviour in directing the system has been carefully demonstrated.

On the premise of the utility maximisation approach, a behavioural model of regional household housing choice per housing submarket is set up. It is argued that the structure of the regional labour market determines household dwelling location choice. The influence of housing submarket marketability (defined as an inverse of the submarket trade friction) on household housing choice behaviour is considered. The family life cycle pattern of housing choice behaviour and the influence of household financial constraints on housing choice are also developed in the model.

The empirical analysis is based on both *Stated* and *Revealed* preference information in order to overcome the dwelling supply constraint. The data is derived from the Lothian Region owner occupier housing market. The empirical results are compared with those of the existing housing choice models.

The policy implications which follow from this thesis are then discussed in the light of the findings

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CHAPTER I INTRODUCTION

1.1. Making Connections

Whilst owner-occupation in the United Kingdom began to expand in the 1920s and 1930s, since the 1950s, home ownership has become consolidated as the most important form of tenure. The proportion of owner -occupied dwellings has increased from 26% in 1947 to 68% of the 1991 total stock of dwellings in the UK (Bacchin 1994). In the last decade, the research in housing economics has primarily focused on the owner-occupier mortgage finance system (Meen 1989, Maclennan & Gibb 1990). Recent attention has been given to the role of housing in the national economy (Maclennan 1994) and the regional structure of the national housing market (Meen 1994). However, there has been limited research on how a local owner occupier housing system is structured and functions. Therefore, the influence of local housing submarket structure on housing choice has been ignored although there is a large volume of literature discussing household housing choice behaviour (Boehm 1982, Quigley 1985). Maclennan & Tu (1995c) argues that this omission is important for at least three reasons:

1. There is a limited body of microeconomics knowledge which can inform the development and estimation of local and regional housing models. The access space model derived from the standard, contemporary Walrasian synthesis of the neo-classical framework (See the discussion in Chapter II) has been dominating urban housing economic research. However, the distinct drawbacks (See Chapter II) of this model have limited housing economists in exploring the complex nature of the urban housing market.

The properties of housing variety, spatial fixity and durability imply that a local housing market is segmented and market trade friction exists inherently (see Chapter II). Previous research on local housing market analysis emphasises the estimates of hedonic house prices (Maclennan, Munro & Wood 1988) and the estimates the local housing demand and supply (Cobb 1984, Quigley 1985), but ignores the market structures and processes which underpin them. Clearly, a new approach aiming at exploring local housing submarket structure and its equilibrium / disequilibrium properties is needed.

2. There is limited research on intra-urban time series studies as opposed to cross-section studies. The dynamics and direction of submarket house prices are unclear. However, this is the key component of understanding area rise or decline, and it can provide important evidence for urban regeneration policy. The recently developed econometric time series technique, namely cointegration analysis, provides an empirical method to investigate housing submarket evolution over time. Therefore an explicit definition of the urban housing submarket structure is needed to underpin the analysis.

3. It is at the intra-urban or metropolitan scale that housing issues interface with housing and land planning systems. Though some analyses (Bramley 1992) have examined housing supply-land planning issues, they have not developed dis-aggregated estimates or models of local systems. McFadden (1978), Boehm (1982) and Quigley (1976, 1983, 1985) estimated the disaggregate local housing demand. However, their work is either based on an individual dwelling or based on a group of dwellings rather than on a local housing submarket and therefore, cannot provide direct information for city planning issues. In this respect, the estimation of disaggregate housing demand and supply on the

basis of housing submarkets is required. The research issues arising from these concerns fall into two groups: The structure and nature of a local housing market, and household housing choice behaviour within this structure. These two issues are further defined in the next section.

1.2 Problem Definition

Housing variety, space and time are not merely real dimensions of choice but also real dimensions of any housing market which may make the likelihood of an instantaneously equilibrating, perfectly competitive housing market rather remote.

The variety of the housing stock arises from a number of different factors. Variety exists explicitly because dwellings are differentiated by dwelling type and size which may be enhanced by the consumers' needs and housing preferences. There is also inherent dimensional variety in that some housing is old and some is new, or housing may be more or less accessible to employment centres may be located in different neighbourhood environments. That is time and space are both inherent shapers of variety.

The temporal dimension of a local housing market reflects the dynamic nature of the local housing submarkets. In the short run, this is reflected by submarket housing price fluctuation around an equilibrium position. The physical dwelling attributes and qualities are assumed to be unchanged, and hence price fluctuation is caused by the change in housing demand and supply in each housing submarket. Within any submarket at a point in time, there may be a dispersion of prices paid for a specific housing attribute

(Maclennan & Tu (1995 c). In the long run, this is reflected by both the price change and the housing submarket structure change arising from physical dwelling attributes and quality changes.

The spatial dimension of urban housing markets was initially given prominence in relation to travel to work time to CBD (Central Business District) employment (Muth 1969). More recent econometric studies allow for multiple household trade-offs in relation to a range of household activities, such as shopping, leisure (Quigley 1985), and a wider spread of activity location, for example CBD and multiple nuclei of suburban employment. Whilst this latter approach is critical in understanding the mosaic of residential location choice within an urban area, it is not enough. This is because space does not merely enter well defined preference sets and budget constraints in housing choices. It also potentially acts as a constraint in the actual choice process, and it does so because dwellings are spatially dispersed across the market (Maclennan & Tu 1995c).

Adopting Lancaster's (1966) approach, housing should not be viewed as a homogeneous good, but as a collection of attributes (or characteristics). King (1976) identifies these attributes as *Site* related attributes, e.g. neighbourhood amenities or physical neighbourhood condition, and *Dwelling* related attributes, e.g. dwelling type, or size.

Quigley (1985) argues that the complex nature of a dwelling gives housing choice three distinguishing features: the bundle of services provided by a dwelling is extremely heterogeneous; a consumer faces a large bundle of dwelling alternatives and selects one and only one dwelling from the bundle each time; the choice involves the selection of a price as well as the other characteristics associated with the dwelling. Maclennan , Munro & Wood (1988) further suggests that the dwellings can be grouped into different *product groups*.

For consumers, Maclennan & Williams (1980) assume that they are rational buyers with the axioms of completeness, transitivity, greed and satiation(see the discussion in Chapter V). Each buyer makes his/her choice as a maximum utility choice. The dwelling which he/she buys can bring him/her more utility as compared to any other dwelling. Therefore, a housing buyer has to undertake an extensive housing search over areas as well as over different types of dwellings in order to find the dwelling which he/she wants. The consumers are also as varied as the housing stock, e.g. they are differentiated by the family life cycle. They are capable of being aggregated into *consumer groups*. The buyers from different groups exhibit different housing search and choice behaviours. The existence of that segmented dwelling product groups and differentiated consumer groups implies that there is a matching process between buyers and sellers as represented in Diagram I(1) below.

Diagram I(1):

The Matching Process of the Buyers and the Sellers In a Housing Market

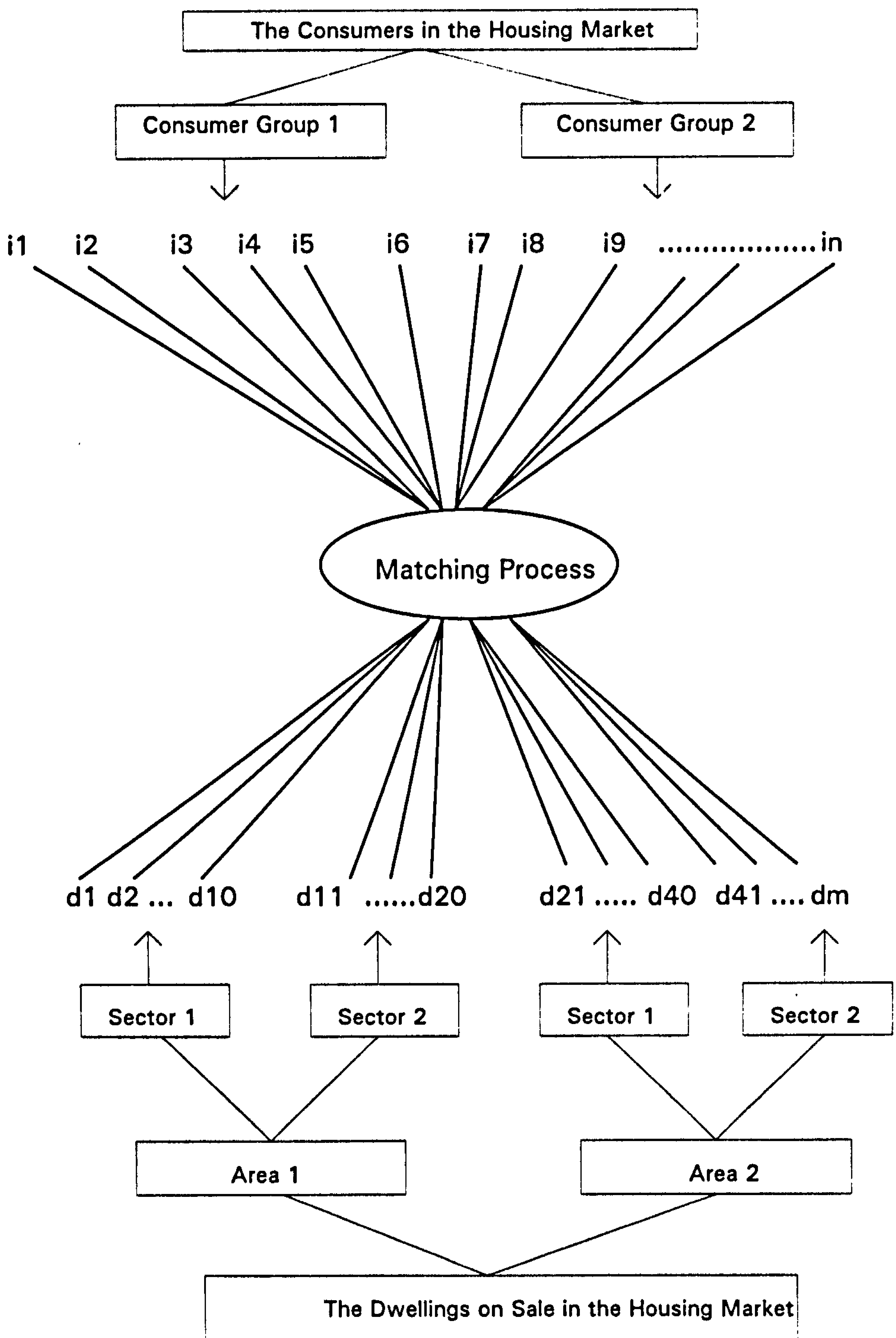


Diagram I(1) provides a framework describing the matching process of housing transactions in a private owner occupier housing market. It is assumed that: 1. there are n individual ($i_1...i_n$) buyers, who are classified into two consumer groups, looking for dwellings; 2. there are m dwellings ($d_1...d_m$) on sale. These dwellings are located in two areas, and within each area there are two dwelling sectors identified by dwelling related attributes (which is in terms of non-spatial variety) since the dwellings are physically fixed. The matching process involves the buyers moving and searching over the areas and sectors. Each follows his/her own path (see the discussion in Chapter III). During this matching process, within each product group, the number of buyers may not be equal to the number of sellers and the number of dwellings transacted is only part of the number of buyers and sellers in the market for any fixed time period.

Two important features of the housing market can be identified from the diagram: first, the housing market is both spatially (neighbourhood) as well as sectorally (dwelling type) segmented into housing submarkets; second, housing demand and supply cannot be matched instantly, instead there exists trade friction in a housing market. Therefore the conventional market equilibrium/disequilibrium theory, which assumes frictionless trade, will not apply to the housing market situation. This raises two theoretical questions in housing economics: 1. can a segmented housing market with trade friction achieve equilibrium? and 2. what are the market equilibrium and disequilibrium properties in such a market?

The matching process also implies that household housing preferences may be the key in directing housing demand into different housing neighbourhood/housing sectors. Any changes in housing choice behaviour may influence the distribution of total housing demand, thus influencing housing market equilibrium. This raises two practical questions: how to forecast housing demand per housing submarket and how the housing submarket properties influence housing choice behaviour.

The answers to the above questions constitute the three major objectives of the thesis.

(a) To define a local housing submarket structure within which both the spatial aspect and the sectoral aspect of a dwelling are considered explicitly.

(b) To develop a mathematical model which is aimed at describing the operational process of a local housing submarket structure. This model will explicitly explore the matching process of disaggregate housing demand and disaggregate housing supply, based on which, housing submarket equilibrium and disequilibrium properties can be derived. In order to simplify the discussion, a local housing market is assumed as demand oriented. Housing supply is assumed to be from dwelling vacancy with a fixed dwelling vacancy rate in the short run.

(c) To develop a hierarchical housing choice model, through which housing demand can be forecast per housing submarket as well as by individual dwelling. This model will explore the link between housing submarket structure and housing choice behaviour. The discussion will focus on a regional housing submarket system.

1.3 Format of Thesis

The thesis is conceptually divided into two parts: the 'local' housing system and its properties (Chapters II to IV) and forecasting household housing choice behaviour (Chapter V, VI and VII).

Chapter II reviews the existing models in housing economics. The review covers a variety of models: the theoretical models concerning housing market equilibrium and disequilibrium properties; the national models concerned with forecasting aggregate housing demand, supply and housing price; the regional models which focus on the regional relationships in terms of housing demand, supply and housing price and the urban models aimed at forecasting disaggregate housing demand, supply and housing price in the urban context.

Chapter III sets out the fundamental definitions used in the ensuing analysis. These focus on the definition of a dwelling; the link between a dwelling and a sectoral housing submarket and a neighbourhood housing submarket in the regional context; the definition of a buyer and the latter's place in the family life cycle and the definition of housing submarket trade friction. A buyer's housing search behaviour is categorised within the context of these fundamental definitions and this lays the foundation for the modelling approach adopted in later chapters.

Chapter IV sets up a revised dynamic stock-flow model with trade friction to analyse housing submarket equilibrium and disequilibrium properties. Based on the mathematical specification of this model, a computer program is implemented to simulate the housing submarket operational process. From the simulation results, housing submarket equilibrium stability properties are derived.

Chapter V develops a conceptual framework for modelling the housing choice decision making process. The framework is based on the nested housing submarket structure discussed in chapter III. It is suggested that a two stage, hierarchical model is needed to forecast housing choice behaviour per housing submarket as well as by individual dwelling. From this framework, a group of co-variates are derived for the purpose of empirical testing. The discussion focuses on a regional housing Submarkets.

Chapter VI discusses discrete choice probability model selection and the data collection procedures used in the research. The multinominal logit model (MNL) and the nested multinominal logit model (NMNL) are chosen to calibrate housing choice behaviour. Chapter VII presents the empirical results.

Chapter VIII presents the conclusions from the research. It includes a discussion of these conclusions, the policy implications of the results and some future study recommendations.

CHAPTER II HOUSING MARKET MODELS: A REVIEW OF THE LITERATURE

2.1 Housing Market Model Classifications

There exist a variety of housing market models and comprehensive classifications of these are given in O'Sullivan (1984) and Carruthers (1988). In terms of the focus of these models, they can be classified into two categories: the theoretical models and the empirical models.

Theoretical models which were developed in order to understand how a housing market actually works. Since the 1960s, urban economists have applied the neo-classical general equilibrium model to the issues of residential and urban structure (Alonso 1964, Muth 1969, Evans 1973, MacDonald 1979). Building on this, the access-space trade-off model was developed and this dominated theoretical and applied analyses until the early 1980s (Maclennan 1982). However, this line of development was de-emphasised as researchers began to take account of the existence of housing market trade friction. The conventional assumption of an instantaneous matching process between housing demand and supply in the neo-classical general equilibrium model is violated by the existence of trade friction. Instead, a dynamic stock-flow model with trade friction was developed (Snickars 1978, Weibull 1983,1984, and Wheaton 1990). This provides a new framework for understanding housing market operation.

Empirical models are aimed at providing housing market demand and supply information and offering explicit housing market forecasting. Most of these models are derived from the general equilibrium model, the utility or the random utility approach. These are three kinds: national models, regional models and urban models. National models assume dwellings in the market are homogeneous and the derivation of these models are either based on a market equilibrium or disequilibrium assumption. Although recently many economists have tried to reveal the spatial interactions between the regional housing markets, regional models have been subject to relatively limited development, especially for the U.K. regional private owner-occupier housing market. It is a very important aspect because the regional housing market is the link between the urban and national housing markets (see Section 2.3.2). Urban models have a variety of model forms and are typically based on the utility or the random utility approaches.

Before focusing on a review of these models, it is useful first to introduce three dimensions of particular importance vis a vis a housing market, namely, space, time and dwelling type. The spatial dimension implies that dwellings are spatially distributed and house prices vary across the market. The temporal dimension implies that house prices may change dynamically. A dwelling is a complex commodity (Lancaster 1966) and can be specified, in a broad sense, by its related attributes including location attributes and neighbourhood attributes as well as dwelling structure attributes including dwelling type, dwelling size, and dwelling age. The need for an explicit definition of these dimentions is because the existing urban, regional and national models tend to differ in terms of their dimensions of specification as well as in their levels of aggregation.

National models are primarily concerned with the temporal dimension. Their theoretical foundation is based on neo-classical general equilibrium theory. Such models are almost completely aspatial and aggregative.

Regional models involve the three dimensions of a housing market identified above. The temporal and spatial dimensions together reveal the long term relationship between the regional house prices (see Section 2.3.2). The dwelling type dimension has received limited attention at regional level. However it is important as, within a region, this dimension together with the spatial dimension can reflect how the regional labour market structure influences dwelling location choice, therefore, shapes the regional housing submarket structure.

Urban models are primarily concerned with the role of space and dwelling type. The theoretical basis of such models is the utility or the random utility approaches which are both the powerful and flexible ways of formulating models of housing market behaviour. Some of the urban models develop the notion of space as a source of transport costs (i.e. land use model, see Section 2.3.3.1). There is also another type of urban models which uses statistical discrete choice models derived from the random utility approach to model housing choice behaviour. Most of these models have been developed in the USA and are more readily applicable to the form of housing market prevailing there (i.e. a high degree of private rental tenure and car ownership), but in the U.K., the market is the owner-occupier tenure dominated.

The above classification captures most of the salient features of housing market models in general, however a closer analysis of these models within each classification is needed in order to develop a tractable model form appropriate to the regional analysis focused upon in this study. The remainder of the current Chapter presents an analysis and critique of these models.

2.2 Theoretical Models of the Housing Market

2.2.1 Neo-classical General Equilibrium Model

The dominant theoretical framework for micro economics of housing markets is the standard, contemporary Walrasian synthesis of the neo-classical framework. In this framework, consumers and producers are assumed to be fully informed and fully rational and the system is usually regarded as competitive. Goods are also assumed to be homogeneous. They are either transportable to the market or capable of full descriptions within the market place. The market, in which fully informed trading takes place, can adjust or clear itself instantaneously during the market trading period.

Applied this framework to a local housing market, the Access Space Trade-Off model (see section 2.3.3.1) is developed. The basic idea is that in the condition of market equilibrium, whilst travel to work cost rises with distance from the centre of a city, land price will fall. The total cost of buying or renting a dwelling is determined by both the individual's travel cost and the dwelling price or rent. Over the last 15 years, this model has been the dominant paradigm of international urban-housing economics research. A variety of application derived from the model have been developed which embody minor rather than major differences (Maclennan 1982). Some of these specifications will be introduced in Section 2.3.

However it has been recognised that this model has limited relevance in explaining the spatial structure of a metropolitan housing market (Maclennan 1993) and the assumption of an instantaneous matching process of housing demand and supply may not hold due to housing search behaviour and the existence of a number of spatially and sectorally separated submarkets. The same type of dwellings located in the different neighbourhoods may have different prices. This means that the two neighbourhoods are within two different neighbourhood housing submarkets (Goodman 1981, Richardson & Thalheimer 1982, Maclennan, Munro & Wood 1988). Within one neighbourhood, the dwellings are differentiated by their dwelling types or sizes and have different house prices. This means that there exist several sectoral housing submarkets in a neighbourhood. A buyer has to undertake a housing search before finding a satisfactory dwelling from the spatially and sectorally distributed dwellings. Housing market trade friction happens.

If the market clearing processes are incomplete or only partly informed and also capable of creating a new dynamic, e.g. the effect of rising real house prices on consumer and institutional beliefs, then the mainstream paradigm may throw out important questions in the process of making the model assumptions. In other words, the conventional neo-classical framework in microeconomics leaves no room for frictional slacks and shortages in the matching of supply and demand. A new approach was developed and is discussed below.

2.2.2 A Dynamic Stock-Flow Model with Trade Friction

Market trade friction implies that, in a housing market, there may exist both unsatisfied demands and supplies, even in equilibrium. For example, suppose that in a housing market, there are 50 housing buyers looking for a dwelling and 40 dwellings available. After a time period, 20 dwellings are traded. Thus 30 buyers have not found a dwelling and 20 dwellings haven't been sold. This is because some buyers may need to do more housing search and obtain more information before making a decision, and they adjust themselves gradually to slacks and shortages.

The essence of the dynamic stock flow model with trade friction is summarised as follows: 1. the dwellings are heterogeneous in terms of the temporal (differentiated by dwelling construction dates), the spatial (differentiated by dwelling locations); and the dwelling type (differentiated by dwelling structures) dimension; 2. the model postulates a matching process between the buyers and the sellers over time; 3. price movements are determined by the market, with exogeneously fixed price as one possibility. For example, the model can be extended to describe a housing market where there are private housing with free price formation and market trade on the one hand, and public housing allocated through a rationing system at administratively fixed prices on the other hand; 4. equilibrium is defined in terms of equality between the extra housing demand, supply and the amount of dwelling traded over time. '*Due to the trade frictions, there are generally simultaneous 'shortages' and 'slack' in all segments of the housing market, even in equilibrium*' (Weibull 1983, Page 374).

This model provides a useful theoretical framework in explaining local housing market operation. However, the application of the framework to a regional or urban housing market has not been researched in the aspects of empirical specification of the model, the discussion of equilibrium stability as well as the policy implications of the model. In order to remedy these defects, a development and application of the approach is given in (Chapter IV).

2.3 Empirical Models of the Housing market

2.3.1 National Models

National housing market models are generally based on temporal dimension. The data used are time series data at the aggregate (and hence aspatial) level. The model specification depends on the intended purpose, and is broadly classified into two types. The first is as a means of forecasting and normally uses a reduced form equation; the second is aimed at explaining the housing market mechanism and a structural form equation is generally used. However some reduced form equations have been employed in an explanatory role, so the boundaries are not distinct (i.e. O'Sullivan 1986).

In a housing market, the general form of a national model is presented as:

Demand Function $DH = f_1 (Ph, Px, \Delta Ph, \Delta Px, Y, Z_1)$

Supply Function $SH = f_2 (Ph, \Delta Ph, Cf, Z_2)$

Where: DH and SH are the demand and supply for housing; Ph is the house price and ΔPh is the house price change; Px is the price of all other goods; Y is the income level; Z_1 is the financial availability on the demand side; Cf is the cost of input factors and Z_2 is the financial availability on the supply side. For simple reason, subscript 't' representing time is omitted from the model.

From this common framework a number of models have been developed both in the U.K. and the USA based on different principles (Whitehead 1974, Artis, Kiernan & Whitley 1975, Hadjimatheou 1976, Nellis &Longbottom 1981, O'Sullivan & Drake 1993). The models not only vary in their treatment of house price endogeneity, their stock or flow specification, and their equilibrium or Disequilibrium formulation, but also vary in their employment of different statistical techniques. In terms of the latter, there are two typical national models. One employs the partial adjustment principle; the other employs the error correction methodology (ECM).

The studies by Whitehead (1974), Artis, Kiernan & Whitley (1975) and Hadjimatheou (1976) all incorporate the partial adjustment principle when modelling the demand side of the UK housing market in terms of either partial adjustment of demand for the stock of owner-occupier housing, or for the flow of new housing into the market. The basic partial adjustment principle is shown below:

$$X_t - X_{t-1} = \phi(X^*_t - X_{t-1}) \qquad (0 \leq \phi \leq 1)$$

where; X_t is the existing stock at time t; X^*_t is the optimal value of the stock concerned, which represents the long term trend and φ is assumed as an adjustment parameter being independent of short run economic influence. However, this assumption is highly unsatisfactory in reality because the term φ , in general, is a variable influenced by both the short term and long term economic environment, not just a parameter.

Nellis & Longbottom (1981) and O'Sullivan (1986) both develop a reduced form model of house price determination incorporating the ECM approach. In their models, short term house price dynamics is adjusted by an error correction term. The basic principle is:

$$\Delta Ph_t = \alpha * \Delta X_t - \beta * (Ph_{t-1} - Ph^*_{t-1})$$

Where; Δ is the difference; α and β are parameters; X_t is a vector of social economic variables and Ph^*_{t-1} represents the long tern trend of house price. In their models, the error correction term is proved to be significant.

After the mid 1980s, the time series Cointegration methodology was developed (See Section 2.3.2). The cointegrated error correction model is developed, and then, widely accepted as a time series forecasting model. Drake (1993) uses the Johansen technique (Johansen 1988) of Cointegration analysis to estimate a parsimonious dynamic error correction model for UK house prices. His study derives a long term equilibrium relationship for the determination of UK house price and then based on it, he develops a short-run dynamic model of UK house price. The results indicate that in the long term, real personal disposable income is a very important driving force behind fluctuations in UK house prices with real mortgage rate and private sector house start having more modest influences. In the short term, however, it is the lagged changes in both private sector house start and house price which drive short term fluctuations in UK house price.

Nevertheless national models are generally parsimonious in terms of data requirements and tractable in its explicit formulation of the elasticities and are therefore the valuable models in exploring the temporal housing market operation at macro level.

2.3.2 Regional Models

Within the housing market modelling literature, analysis at regional level is a relatively undeveloped area. However some models, mostly developed after the mid 1980s and aimed particularly at the regional level of aggregation, do exist. These models mainly focus on explaining regional housing market interaction. A brief review of these models are given below.

Carruthers (1988) develops an equilibrium model of the Scottish housing market using mainly 1981 Census data on 56 administrative districts within Scotland. This is a cross-sectional analysis. The theoretical model is summarised below:

Demand Function	$DH=-A*Ph+X_1*M_1$
Supply Function	$SH=B*Ph+X_2*M_2$
Price Function	$\Delta Ph=\Gamma*(DH-SH)$

Where: DH, SH are n*1 vectors of quantities demanded and supplied respectively at the prevailing n*1 price vector Ph; A, B are n*n matrices of slope coefficients (elasticities in the log linear model); X_1, X_2 are n*k exogenous variables; Γ = n*n matrix of market adjustment speeds; M_1, M_2 are k*n exogenous variable coefficients; 'n' is the sample size, here 'n' is equal to the total number of districts within Scotland and k is the number of exogenous variables considered.

Matrix A represents spatial demand substitution in response to the relative (spatial) price changes between the districts and matrix B represents the substitution in production of housing in different districts in response to price changes throughout the districts.

Matrix Γ reflects price changes responding to market conditions and particularly the behaviour of housing market professionals who are assumed to act as Walrasian auctioneers. This means that the housing market professional can correctly assess the degree of excess demand or supply prevailing in his own area and adjust price recommendations as appropriate. For example, if Γ is diagonal, the implication is that each area has its own speed of adjustment independent of other areas.

The empirical application of this regional model gives a number of results which have proved fruitful for this research. The results show that spatial models fit better than aspatial models. First, spatial effects are strong at the inter-district level in the Scottish housing market. Second, the Scottish housing market displays a high degree of interdependence between various subcategorises of demand and supply. Third, this interdependence is dynamically stable, but the fact that such an equilibrium is tractable in the Scottish housing market does not readily generalise the model to the rest of the U.K. which has a different legal framework and structure of economic activity.

The second type of regional model focuses on both the temporal and the spatial dimensions of a regional housing market, the so-called Cointegration analyses of regional housing prices. Such models are aimed at explaining the dynamics of interregional house prices. For example, if there is a stable long-run equilibrium relationship between the regional housing prices or if there is a segmentation of house prices in Britain (MacDonald & Taylor 1993, Alexander & Barrow 1993 and Meen 1994).

Briefly, Cointegration analysis includes three parts: integration analysis, which is developed to test if a time series is a stable one; Cointegration analysis, which is developed to test if a group of time series variables have a long term equilibrium relationship; and error correction model, which is developed to estimate an econometric forecasting model capturing both long term trend as well as short term dynamics. It has been proved that the necessary and sufficient condition of two variables have an error correction representation is the two time series are cointegrated (see Charemza & Deadman 1992).

Based on this technique, Alexander & Barrow (1993), Macdonald & Taylor (1993), Holmans (1990) and Hamnett (1988) give empirical evidence that South East and Greater London are the most dynamic regions in terms of housing transactions. South West and East Anglia are following the changes of South East and Great London house prices. West and East Midlands as well as York are further lagged of the changes of South East and Great London. North and North West are relatively independent of South East house price change. Scotland, Wales and North Ireland are even more independent. The gap between North and South is widening with a tendency also for price movements in the South to lead those in the Midlands and the North.

Meen (1994) has found and tested that spatial interaction is potentially important in UK housing markets. He argues that if spatial heterogeneity is important, then typically aggregation conditions will not hold and we can expect parameter bias and predictive failure from aggregate time-series relationships. His paper also throws light on the issue of how to define a housing market. Under his approach, a market should be defined on the basis of sub-markets, where different model coefficients may exist.

Muellbauer & Murphy (1994) also finds out the income elasticity of demand for housing on a regional basis is around 2. Thus a 10% income differential implies a 20% house price differential between the regions.

Both of these regional models suffer the same limitation of ignoring the existence of the dwelling type dimension within in a regional housing market, for example, the inter-link between regional labour market and regional housing market lacks of empirical evidence, particularly, household housing choice behaviour in a regional context is still unclear.

2.3.3 Urban Models

Urban models can be classified into three types:

- Land use models and segmented market models
- Simulation models
- Disaggregate choice models

2.3.3.1 Land Use and Segmented Housing Market Models:

The essence of these two models is that all employment is located in the central business district (CBD) and that work place position dominates the household choice of a dwelling location. Space is considered as a transport cost. Utility maximisation is the theoretical foundation for both modelling approaches (Alonso 1964, 1978).

The land use model assumes that housing market is in the long run equilibrium. The price of a unit of dwelling service is only determined by the distance from the CBD (central business district). This is facilitated by the assumption that the dwelling choice set is continuous in terms of the distance. The model implies that a household will locate where the saving in transport cost from locating marginally closer to the centre is just balanced by the additional housing expenditure which will be incurred.

The segmented housing market model presents that housing choice is dominant by the housing characteristics or attributes. Utility can be described as deriving from the fundamental attributes which an individual chooses by constructing combinations of available goods so as to maximise utility. The drawback here is that dwelling units are available in discrete (not continuous) service units (e.g. a kitchen is a discrete service unit) which necessarily precludes most households from owning more than one unit.

Both models share the main drawback in that they assume the locating households are immigrants to the urban area and can costlessly locate anywhere; this entails the further assumption that the locating household's decision is in no way dependent on its prior residence. Such an assumption is clearly inconsistent in the presence of housing search behaviour and housing market trade friction.

2.3.3.2 Simulation Models

Disaggregate households as well as house types considerably increase the complexity of housing market analysis and make it more difficult to define the long run equilibrium properties. Simulation models are designed to incorporate such complexity and view the essence of housing market problem as the allocation of the households to the dwellings, and obtain a solution within an explicitly temporal framework. The most famous simulation models are the UI model (Urban Institute) and the NBER model (National Bureau of Economic Research). Both were designed for the mainly rental housing market in the U.S.A. and have been used there for many years.

The UI model developed by De Leeum & Struyk (1976) is an equilibrium model. The demand side, a group of households who are seeking dwellings, is classified by race, age and income. The supply side is classified into three groups: 1. owners of existing dwellings; 2. the government; 3. construction companies. The dwellings are characterised by the quantity of housing services supplied. The housing service assumption and household housing choice are made with respect to the available price-quantity configurations as well as the characteristics of the zone in which a dwelling is located. The characteristics are accessibility, race and the average net rent per dwelling, the latter two being endogenous. The model generates a series of prices giving the distribution of prices per unit of housing services for a variety of structures representing the quantity of housing services. Such a distribution is termed a price-structure curve. It is used to simulate exogenous effects such as an increase in construction costs, a decline in population growth, a housing allowance programme and new construction subsidies.

As an indicator of long run trends, the UI model remains an important contribution to the study of housing market dynamics. The most important feature of the UI model is its consideration of the matching between the disaggregate housing demands and supplies. However, the main criticism about the model is its assumption of market equilibrium.

The NBER model is more complex (Ingram & Ginn 1972). It consists of a series of submodels e.g. movers submodel, vacancy submodel. The most noticeable difference between the NBER model and the UI model is the treatment of the economic base. The NBER assumes that employment location is a fundamental constraint on residential location (the implication in the NBER model being that all the residents in one zone work in the same place), whereas the UI model imposes exogenous trend costs, e.g. the transport cost, for each residential zone. Because of the assumption of workplace dominance in the NBER model, the first step in the simulation process is the employment location submodel, which describes how and what kind of employment location a mover is going to choose. Then, on the demand side, movers are generated by the application of historical mobility rates to household class (mover submodel), and this is subsequently modified by workplace specific alteration (employment location model). A mover chooses house type first and then residential location on the basis of minimisation of travel to work costs (demand allocation model).

On the supply side, houses come from three sources. Vacancies are created by movers, out-migrants and income/household specific changes in occupancy rates (vacancy submodel). Supply can also change via changes in the quality level (filtering submodel), e.g. natural depreciation of a house or conscious upgrading by owners and finally, new house supply is created by government and construction companies (supply submodel).

The last stage in the process, the market clearing submodel, carries out a variety of accounting procedures (e.g. updating the pattern of worktrips). For the purpose of achieving market clearing, households can substitute locations according to previous prices, but not house types. In practice, there is no one to one allocation of households to houses. Excess demands (unallocated households) are carried forward to the next period and expected prices are updated for the next iteration (each iteration happens after one year). Thus the equilibrium to which the model tends is a moving target.

These models are designed however for a mainly rental housing market, but in the UK the owner-occupier housing market dominates, rendering the applicability of the above models highly problematic in the UK context.

2.3.3.3. Disaggregate Housing Choice Models

The assumption of the disaggregate housing choice model is that whilst a variety of factors may be important in determining the likelihood of any one individual making a particular choice, the relationship between the explanatory variables and the choice probability is non-linear. Statistical discrete choice models derived from the random utility approach are commonly used. From the work of McFadden (1973, 1974, 1976a, 1976b, 1976c, 1978, 1979, 1980, 1982, 1984, 1986), a variety of empirical housing choice models have been derived. A critical review of these models is given below.

Struyk (1976) examines the tenure choice process and points out that tenure is important in housing analysis because of housing's dual role as an investment and as a consumption good. There exists interdependence between the owner and rental housing market since both compete for housing services whilst only the owner's demand can be viewed as partly for investment purposes.

Li (1977) successfully uses a logit model to examine all possible multidimensional interaction effects of homeownership, e.g. the interaction between age of the head of household and homeownership, and income or budget influences on homeownership. The research shows that, of the three variables, age of household head, income and family size, age has the strongest non-linear and positive relationship with homeownership and family size has the weakest non-linear and positive relationship with it. Of the interaction terms, the coefficients of income-family size interaction and age -family size interaction are both statistically significant.

Jones (1978a) examines the sequential nature of the residential-mobility decision making process in the UK. A two stage model is considered: the decision to move and the choice of tenure. He finds that life-style and demographic factors have stronger influence on the change of tenure by moving than on the decision to move. The age of the head of the household is generally the most important discriminator.

Kent (1985) gives some time series evidence on housing tenure choice. He indicates that the expected return from owner-occupied housing is an important determinant of tenure choice and the UK housing subsidy programs have had substantial effects on tenure choice.

Research on the housing market which only focuses on tenure choice analyses is too limited. Buying a dwelling also involves a choice of the dwelling and a choice of the related neighbourhood attributes.

King (1980) argues, however, that households' choice of tenure and demand for housing services are a joint decision. He points out that it appears important to allow preferences to be distributed across the population. This implies that there is a distribution of price elasticities of demand across consumers which is both interesting in itself and significant for an analysis of the welfare gains and losses from housing subsidies and tax policy.

Kent (1983) points out there are three distinct decisions pertaining to the demand for housing: 1. household formation ; 2. tenure choice, and 3. how much housing to consume, given household formation and tenure choice.

Quigley (1976) estimates a conditional Multinominal logit model to analyse housing choices. He points out the distinction between the service price and the gross price which is influenced by travel to work cost. He then estimates the model with the sample split by income and family size, with the relative likelihood of anyone choosing a house type as a function of travel to work cost, neighbourhood dwelling density, size, (rooms), quality (age), availability and the relative price of each house type. Quigley's work shows that it is unwise to ignore house types and the effects of travel to work costs on choice, but the main drawback is that the model is based on samples which are renters, so the results cannot be generalised to an owner occupier housing market.

Louviere (1979) explores the potential for estimating individual utility function in housing choice and for testing the differences between the utility coefficients as a function of interpersonal factors. He concludes that it is possible to estimate individual choice functions for the general population and that these functions can include a fairly large number of housing attributes, at least 13 and probably as many as 20-25, using stated preference experimental design. However such design may bring some biases into the model because of the possibility of an individual over or under estimating his/her demand for housing services. This is addressed later in this study.

Boehm (1982) argues that house type choice and tenure choice cannot be treated independently. He views tenure, size and quality choices as occurring within a 'hierarchy' of choices. A consumer is viewed as making the tenure choice first. The order in which the subsequent choices is made is conditional on the tenure choice, and will vary between individuals. He classifies the model into three hierarchies, the first is tenure choice, the second is quality choice and the third (lowest in the hierarchy) is size choice. Each hierarchy is treated as dichotomous (binary logit), therefore, eight possible housing choices are created.

Borsch-Supan (1986) specifies and estimates a nested logit model of housing demand which includes the decision of individuals to form an independent household. Parameter estimation reveals a considerable response of headship rates not only to income but also to housing prices. He points out that analysis of housing policies ignoring the endogeneity of household formation is thus potentially biased.

Quigley (1985) develops a nested logit model of a limited number of alternatives to estimate household choice of dwelling, neighbourhood and public services. He points out three distinguishing features of housing choice. First, in almost all cases, a consumer selects one and only one good out of a large population of alternatives; 2. the bundle of services provided by any dwelling is extremely heterogeneous; 3. consumer choice involves the selection of a price as well as other characteristics associated with dwellings. From the statistical point of view, his model is a type of nested logit model which is designed to avoid the axiom of Independence from Irrelevant Alternatives (IIA) implied by the traditional Multinominal logit model (This is discussed in Chapter VI). He argues that the axiom is inappropriate in many situations involving the choice of housing and neighbourhood characteristics. In this model, McFadden's sampling rule (McFadden 1978) is introduced into the model to reduce the number of alternatives at each level of the nested logit model. This, to some extent, overcomes the practical problem in maximising the log-likelihood function of a nested logit model due to the large number of alternatives in housing choice. From the economic point of view, the model also provides a good framework to consistently examine household preferences for dwelling structure attributes, neighbourhood attributes as well as public services. However, the main criticisms of the model are that some arguments are not theoretically consistent. 1. The precondition of McFadden's sampling rule adopted by this model is that choice behaviour is assumed to satisfy the axiom of IIA implied by the traditional multinominal logit model. However, the model developed in this paper is based on the argument of the invalidation of the IIA axiom in a housing choice case. 2. In the real world, a dwelling is only rejected once when a household makes a choice. But in this model, a dwelling is assumed to be rejected three times separately at the stage of town choice, neighbourhood choice and dwelling choice.

Blackley & Ondrich (1988) develops a limiting joint-choice model for discrete and continuous housing characteristics. They point out that household utility depends on three characteristics of housing: a discrete number of bedrooms and continuous measures of housing quality and distance from the central business district. For this reason the traditional Multinominal logit models and nested logit models which have been used to analyse polychotomous discrete choices are not applicable when utility is a function of both discrete and continuous choice variables. Instead the empirical results show that a simultaneous discrete and continuous random utility model within the GEV (General Extreme Value) framework is the most suitable model in modelling housing choice. However the argument of the model is based on the assumption that housing quality can be measured as a continuous variable. In fact it is very difficult to find a suitable indicator representing housing quality. An inaccurate measurement of dwelling quality may cause estimation bias.

The main advantage of using hierarchical or nested models is the ease of interpretation since the decisions in each hierarchy are treated as separate and the independence from irrelevant alternatives assumption used in the traditional multinominal logit model can be avoided. However, this does not imply that a hierarchical model is superior to the traditional MNL model. Further discussions about the properties of discrete choice models will be given in Chapter VI.

Four disadvantages shared by the above models are discussed below.

1. These models lack economic underpinning. They do not give a clear explanation of the possible interaction between household housing choice behaviour and housing market operation.

2. The existence of housing submarkets and the differences of the submarkets, e.g. submarket house price, submarket trade friction, may influence housing choice behaviour. But the above models do not pay any attention to this relation.

3. Most of the models focus on urban housing market. The basic difference of a regional housing market from an urban housing market is that, regional housing market covers more than one employment centres (generally, there is one CBD surrounded by several sub-CBDs), and urban housing market has only one employment centre, namely CBD. As the distance to the work place is recognised as an important factor influencing dwelling location choice (Alonso 1964, 1978 and Quigley 1976), the shape of a regional employment distribution may be an important factor influencing housing choice behaviour, therefore, determine the structure of a regional housing market. However, previous models ignore this effect.

4. Most of the hierarchical models assume a choice sequence, for example, Quigley (1985) assumes that the choice sequence is the public services first, then the neighbourhood, and finally the individual dwelling. However, different buyers may have different choice sequences and some may make their choice of dwelling related attributes simultaneously. Simply assuming a choice sequence in a hierarchical model is unreasonable. A crucial question is whether the sequence used in the hierarchical models has the same meaning as the sequence used in describing housing choice behaviour.

A new regional housing choice model per submarket is needed to remedy the above disadvantages. The discussions of the new model are given in Chapter III and then in Chapters V to VII.

2.4 Two New Models

Concluding the above review, we find that there are two gaps in micro economic housing research which need to be addressed.

The first is local housing market operational process and its equilibrium and Disequilibrium properties in the presence of housing submarkets and submarket trade friction lack of research. The second is that little attention has been paid to disaggregate housing choice behaviour in a regional housing market.

Therefore, two new models are needed to remedy the above defects. The first model (see Chapter IV) is a revised form of dynamic stock flow model with trade friction. In this model, the dynamic stock flow approach is applied to both a spatially and sectorally segmented local housing market, it is assumed that in a local housing market, short run dwelling supply is from the dwelling vacancy with a fixed dwelling vacancy rate; the influence of submarket trade friction on housing submarket equilibrium and disequilibrium is considered; the relationship of housing submarket equilibrium and disequilibrium properties and housing choice behaviour is emphasised and finally a computer program is implemented to simulate housing submarket operational process and its equilibrium stability. The aims of the model are to fully understand a local housing market system and its properties. This model can be applied to either an urban housing market or a regional housing market.

The second model required is a hierarchical housing choice model in a regional context (see Chapter V). This is a functional framework, on the basis of which disaggregate housing demand can be forecast per submarket as well as by individual dwelling. A group of covariates are derived from the theoretical framework to explain housing choice behaviour in a regional housing market context. In this model, the influence of housing submarket factors on housing choice behaviour is considered, and travel to work distance is considered as a key factor influencing a buyer's choice of dwelling location. The multinominal logit model and the nested multinominal logit model are selected for empirical calibration of each model (see Chapter VI). The merits and limitations of the two models are empirically compared. The results are presented in Chapter VII.

Before the two models are built up, it is necessary to define a local housing submarket structure. Although a plenty of research have proved the existence of local housing submarket (i.e. Goodman 1981, Maclennan, Munro & Wood 1988), the definition about its structure is still underdeveloped. Precisely defining a local housing submarket structure will provide a basis of understaning a local housing market. This constructs the content of Chapter III.

CHAPTER III THE DEFINITIONS OF A LOCAL HOUSING SUBMARKET STRUCTURE AND SUBMARKET TRADE FRICTION

3.1 Introduction

This chapter defines the concepts used in the analysis later in the thesis. It was established in Chapter II that there is a need to precisely define a local housing submarket structure. The definition can provide a basis of discussing and exploring local housing submarket operational mechanism. Section 3.2 gives the definition of local housing submarket structure. Section 3.3 presents the definition of a housing buyer and provides a comprehensive classification of the housing buyers in terms of their social economic backgrounds. Section 3.4 defines local housing submarket trade friction.

3.2 Local Housing Submarket Structure: a regional case

3.2.1. Definition of a Dwelling

Lancaster (1966) developed a new approach to consumer theory and gave a definition of a complex commodity. *' 1. The good, per se, does not give utility to the consumer; it possesses characteristics, and these characteristic give rise to utility. 2. In general, a good will possess more than one characteristic, and many characteristics will be shared by more than one good. 3. Goods in combination may possess characteristics different from those pertaining to the goods separately.'* (Lancaster 1966, Page 135)

The approach defines a complex commodity having more than one characteristic. Some of the characteristics are related to the commodity itself, some of them are the characteristics of the commodity as a group. Using this approach, a dwelling can be described as a complex commodity which has the following six characteristics (or attributes).

1. A person views the dwelling which he/she is going to buy as a bundle of characteristics, e.g. dwelling structure, dwelling size; it is the characteristics which he/she values, and the decision to buy one or another bundle (dwelling) is influenced by the relative efficiency (utility) of each as a source of supply of the constituent characteristics.

2. Dwellings are unmoveable and spatially distributed. This property determines that the site characteristics, e.g. physical neighbourhood condition, neighbourhood amenities or neighbourhood school quality are the common characteristics shared by the dwellings located within one site. Choosing a dwelling involves a choice of these characteristics.

3. Any one dwelling is different from another although they may have some common characteristics, like the same dwelling structure, or the same neighbourhood characteristics. The dwelling prices vary from one dwelling to another dwelling, and from one site to another site.

4. Compared with most other commodities, a dwelling is very expensive. As a result, on the demand side, the household financial budget is the main constraint on buying a dwelling.

5. A dwelling is a durable commodity with dual roles: consumption and investment. The consumption of a dwelling is different from consuming a chocolate bar because buying a dwelling is also a family investment. The value of the dwelling may increase or decrease depending on the changes in the site characteristics, the maintenance of the dwelling as well as the general house price inflation. As a result, the decision to buy a dwelling is influenced by the buyer's expectation of future housing price changes.

6. The long construction time and limitations on land use of building a new dwelling result in a supply constraint for a buyer, whether seeking an existing or a new dwelling.

The multiple characteristics of a dwelling produces a severe problem in housing research, which is how to identify or measure these housing characteristics. King (1976) points out that a dwelling consists of four main characteristics: dwelling structure (structure), dwelling quality (quality), interior space (space) and neighbourhood quality (site). Each can be measured by a group of components. For example, the number of rooms or the quantity of the interior square feet are the measurable components of the interior space characteristic. In fact, the identification of the components of each characteristic depends on the data availability and the intended purpose, for example, it depends on whether we want to forecast the number of rooms demanded or the lot size occupied by a dwelling.

Quigley (1985) identifies dwelling characteristics as: public services measured by school expenditures, percentage of non-white students in local public school and local public expenditures per household; neighbourhood attributes measured by the proportion of homeowners, median rent, travelling time or proportion of black households; and the dwelling characteristics measured by the dwelling structure, the dwelling age, the number of rooms and bathrooms. However this specification is designed for the rental dominated American housing market. In order to describe the owner-occupier dominated British regional private housing market, a new identification and measurement of dwelling characteristics is needed. The definition used here is developed from King (1976) and Quigley (1985).

First, the dwelling related characteristics are classified into spatial (i.e. neighbourhood characteristics) and non-spatial characteristics (i.e. dwelling characteristics). Second. each characteristic can be described by a group of components. Some of the dwelling components are designed 'Key'. These are the components which can create significant house price differences between the dwellings. Some are defined as 'Non-key' components, which influence dwelling price, but in a secondary way. In Table III(1) below, all components' examples are likely to be 'key' components, except for those contributing to the non-spatial characteristic: '5. Others'.

Table III(1)

An Example of the Classification of Dwelling Related Characteristics and Components

	Characteristics	**Components**
Spatial (Neighbourhood Characteristics)	1. Physical conditions;	e.g. physical dwelling appearance, green land
	2. Amenities	e.g. shops, cinemas
	3. School Quality	e.g. num. of school leavers entering universities
	4. Marketability	e.g. dwelling transaction rates
	5. Accessibility to the CBD or the sub-CBDs	e.g. road, bus or train facilities
	6. Social security	e.g. local crime rate
Non-Spatial (Dwelling Characteristics)	1. Dwelling type	e.g. house, flat
	2. Dwelling size	e.g. num. of rooms or lot size
	3. Dwelling age	e.g. year of construction
	4. Dwelling quality	e.g. construction materials
	5. Others	e.g. kitchen, garden or central heating

An example of the average dwelling price differences in terms of the key dwelling component differences is given in Table III(2). The data in the table show that the similar dwellings located in the different areas have significant different house prices. Different types of dwellings located in the same area have different house prices too. These differences of the dwelling prices originate from the different combinations of the key dwelling components between the dwellings. This implies that the choice of the key components is not only influenced by a buyer's housing preference, but also strictly constrained by a buyer's financial budget.

Table III(2)

An Example of the Average Dwelling Price Differences in Terms of the Key Dwelling Component Differences

	Overall	Small Old Flat	Large New House
The City of Edinburgh	54783 (481)	35432 (111)	61934 (103)
Central Area	36228 (137)	29661 (62)	44102 (11)
Near to the Central Area	52731 (169)	37984 (13)	55241 (59)
Between the Central Area and the Suburban Area	62536 (106)	44048 (34)	67235 (9)
Suburban Area	84741 (69)	51281 (2)	84575 (24)

Data Source: 1992 Lothian Region household housing survey designed for this study. (1989 House Price £).

The number in the bracket is the sample size.

Although the non-key components of a dwelling will certainly influence dwelling price, but the influence is not significant, therefore, the choice of them is much less influenced by a buyer's financial budget. For example, a case study from the survey shows that, the price of a two bedrooms' semi-detached house in Edinburgh with a large kitchen is £39000, compared with the price of £41000 of the same type of house with a small kitchen plus a separate dinning room. This case study shows that although these non-key components contribute to the dwelling price difference, the price difference is not as significant as the one contributed by the key components.

Unlike Quigley (1985), in this definition, the public services (referring to a town) and the neighbourhood attributes (referring to a neighbourhood within a town) are combined as the neighbourhood characteristics. The reason is that public services, like the accessibility to the CBD, and the neighbourhood characteristics, like the physical appearance of the dwellings, are both related to the spatial aspects of a dwelling. When a buyer chooses a place to live, both factors will together influence his/her choice.

Unlike King (1976), in this definition, the dwelling components are split into key components and non-key components. This is because not all the components are of the same importance to either house price formation or to housing choice behaviour.

The advantage of the above definition as described in Table III(1) is that it provides a theoretical foundation for identifying local housing submarket structure and for forecasting household housing choice behaviour.

3.2.2 Definition of a Housing Submarket Structure

The following definition is an extension of the work of Maclennan, Munro & Wood (1988). Three concepts are introduced first: the hedonic housing price; the hedonic function, and the dwelling product group. The hedonic housing price is the implicit or shadow price of a dwelling component. Empirically, it can be measured by the coefficient of the component in a hedonic regression function. The hedonic function is a regression function. The dependent variable is the dwelling price and the independent variables are the components of the dwelling characteristics. The dwelling product group is a group of dwellings classified by the key dwelling components. The classification is completed both spatially and sectorally. Spatially, the dwellings in one neighbourhood form one neighbourhood dwelling product group. Sectorally, within each neighbourhood dwelling product group, the dwellings can be divided into different sectors, e.g. small flats and large flats are grouped into two different sectors. Each sector forms a sectoral dwelling product group.

A neighbourhood housing submarket can be defined to exist if there are persistent significant disparities in the hedonic house prices of the non-spatial, key dwelling components between the neighbourhood product group and others.

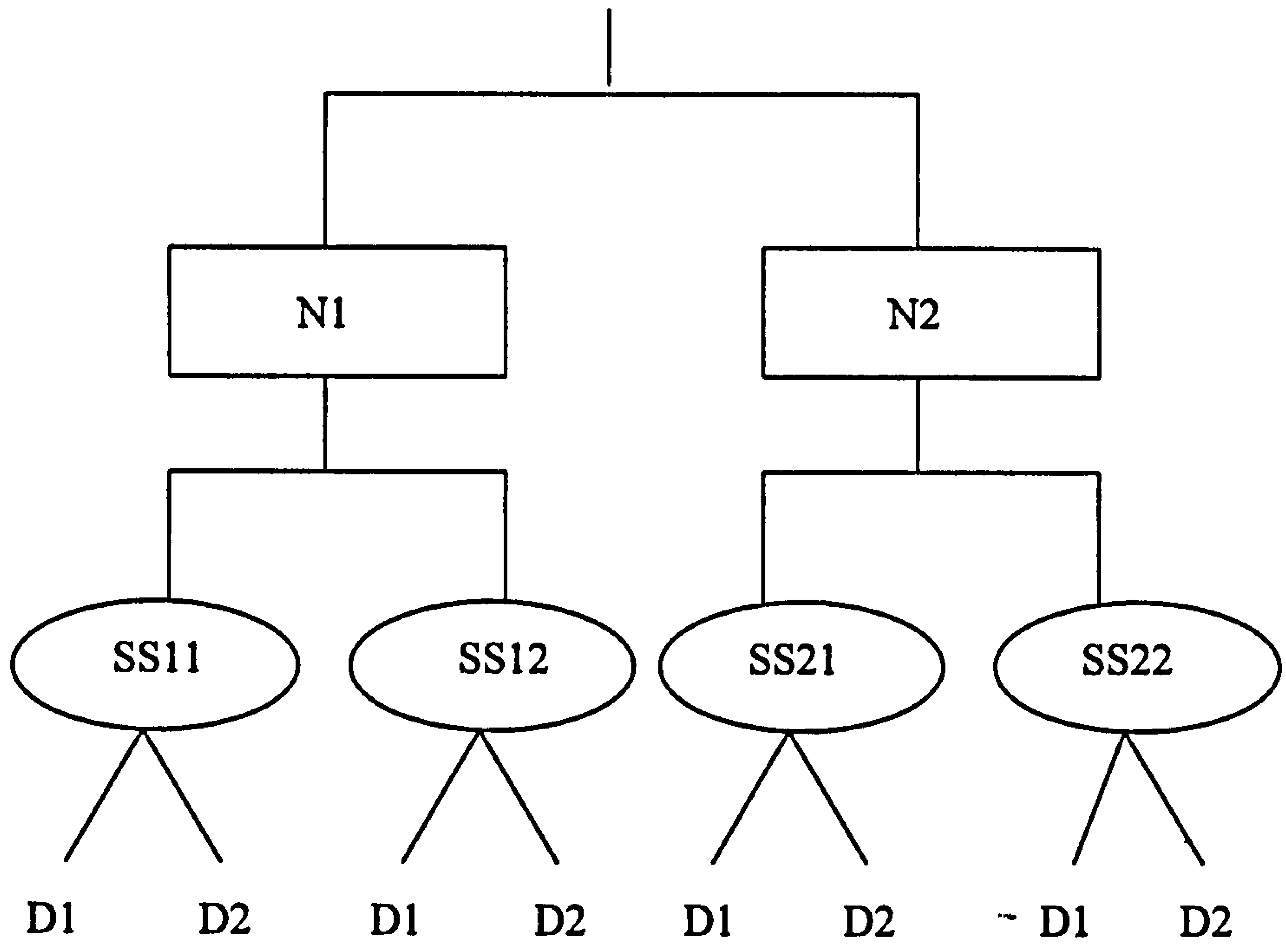
Where two dwellings in the same neighbourhood submarket have significantly different overall house prices, they belong to two different sectoral housing submarkets by definition.

The dwellings within each sectoral housing submarket are only different in terms of non-key dwelling components, and the differences of their house prices are not significant enough to classify them into different housing submarkets.

Diagram III(1) shows a simple case of the connection, between the dwellings and the housing submarkets.

Diagram III(1)

Nested Housing Submarket Structure



This housing submarket structure is defined as a nested housing submarket structure. In the diagram, 'N' denotes a neighbourhood housing submarket; 'SS' denotes a sectoral housing submarket; 'D' denotes an individual dwelling. The advantages of defining structure in this way are as follows.

1. This structure defined above reflects the complexity of a dwelling. The neighbourhood housing submarkets are formed through differences in the spatially fixed neighbourhood components and the sectoral housing submarkets are formed through differences in the non-spatial dwelling components. The differences between the dwellings in each sectoral submarket arise from the non-key dwelling components.

2. This structure presents a hierarchical dwelling supply framework, which provides a useful foundation for discussing local housing submarket equilibrium and disequilibrium properties (to be discussed in Chapter IV) and household housing choice decision making process (to be discussed in Chapters V to VII).

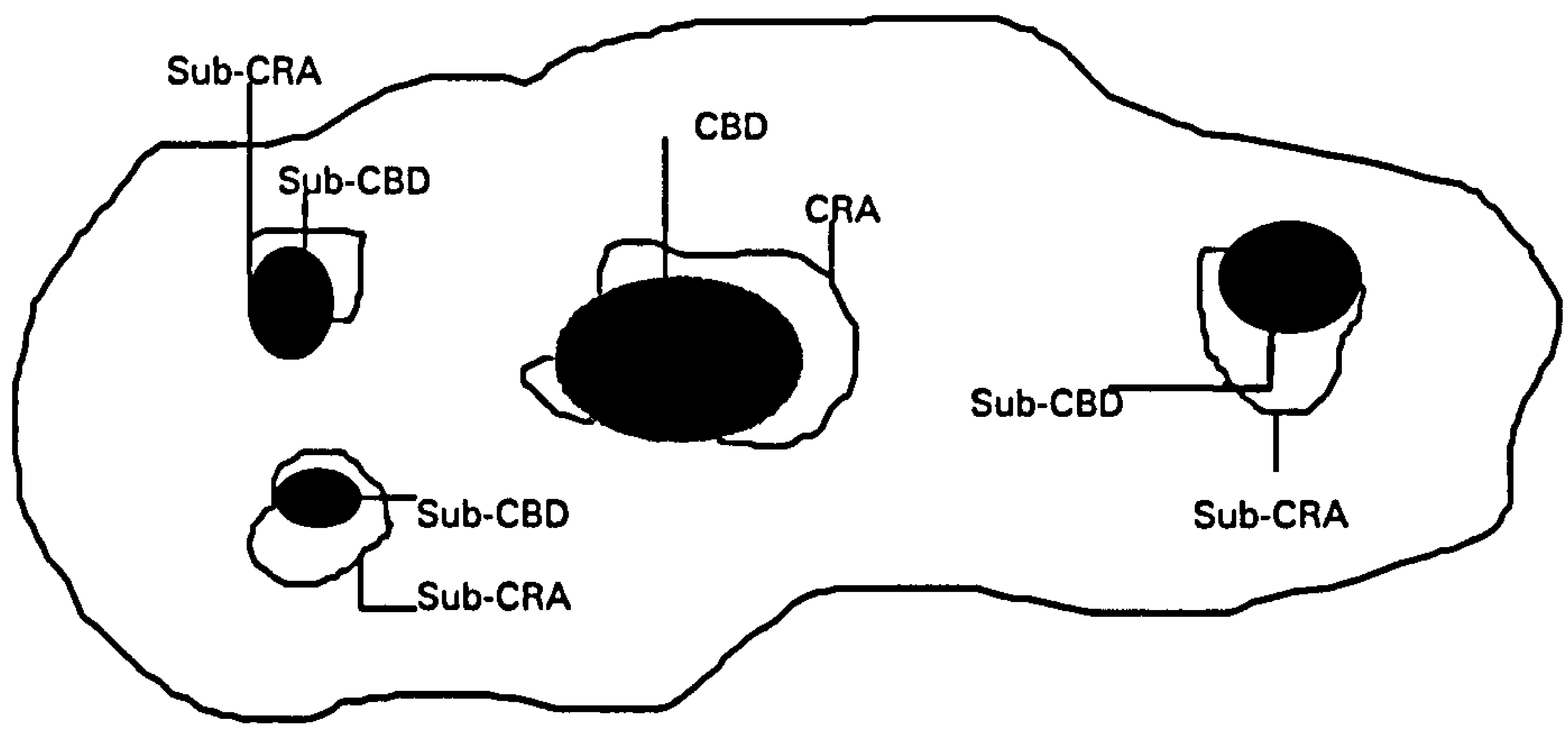
3.2.3. Regional Owner Occupier Housing Market

The definitions discussed above can be applied to either an urban housing market or a regional housing market. In this section, an identification of a regional owner occupier housing market is given. This is because the discussions in Chapters V to VII will be based on a regional housing market as emphasised in Chapter II. Therefore, the discussion below will provide a theoretical basis for the discussions in the following chapters.

Geographically, a regional housing market area interacts with the regional labour market area (See Diagram III(2)). The structure of a regional labour market can be described as: a main employment centre surrounded by a group of sub-employment centres. This main employment centre is usually located within the CBD, and the sub-centres are separately located within the sub-CBDs (See the dark points in Diagram III(2)). This regional labour market structure is named as nuclei structure, which is different from an urban labour market where there exists only one central business district. This nuclei structure shapes the regional residential distributions (See Diagram III(2)), which is that, majority of the households live in or around the CBD forming a central residential area (CRA), the others live in or around the sub-CBDs forming the sub-central residential areas (Sub-CRA).

Diagram III(2)

A Regional Housing Market Area



Considering a household in which only one person has a job, if he/she is working in the CBD, he/she can either live in the CRA by paying a higher house price and a lower transportation cost, or live in one of the sub-CRAs by paying a lower house price and a higher transportation cost. If he/she is working in a sub-CBD, he/she can either live in the sub-CRA by paying both a lower house price and a lower transportation cost, or to live in one of the adjacent sub-CRAs or CRA, by paying a higher transportation cost (in this case, house price can be either lower or higher). The choice depends on the household's preference.

Hence the regional labour market area is the best approximate geographic unit within which to define the regional housing market area. One available approximation to an empirical definition of local housing market areas in Great Britain is the Local Labour Market Areas (LLMAs) of the Functional Regions Framework developed by Coombes et al (1982).

A general description of LLMAs is given by Coombes et al (1982): There are 280s LLMAs (34 in Scotland) across Britain. Each has its main urban centre, by which each is known. Each includes all contiguous areas which in 1971 supplied more commuters to their centre than to any other recognised centres. The level of self-containment approach divides Great Britain into a set of relatively independent places.

However this division was given based on the data 20 years ago. The boundaries of the LLMAs may have changed. Although the revision work is being carried out by researchers using 1991 census data, the results haven't come out yet. Some modifications may be needed when using the existing LLMAs to define a regional housing market boundary. For example, in Lothian Region, the owner-occupier housing market area is defined as the Edinburgh Labour Market Area, (ELMA) but including Bathgate and Blackburn. Twenty years ago the Bathgate and Blackburn areas were excluded from the regional housing market area, now they are treated as a part of the regional housing market area with improving housing marketability because of the development of the transport system (Lothian Region Structure Plan 1993). This boundary is a bit smaller than the Lothian Region administrative area.

Regional housing market is both spatially (neighbourhood) and sectorally (dwelling type) segmented. Spatially, the dwellings in the same neighbourhood are assumed to have similar distances to the CBD, similar dwelling prices and also similar structures of the dwelling types. Sectorally, the dwellings in the same sector are assumed to share the same neighbourhood facilities and to have similar types of dwellings.

An empirical identification of Lothian Region neighbourhood and sectoral dwelling product groups are given in Chapter VII. In that chapter an empirical nested housing submarket structure is set up.

3.3 Housing Demand

The sources, types and natures of housing demand can be more readily defined in terms of the housing 'buyers' and two important constraints, namely, imperfect housing market information and different levels of market information, focusing on the latter which gives rise to trade friction in the housing market.

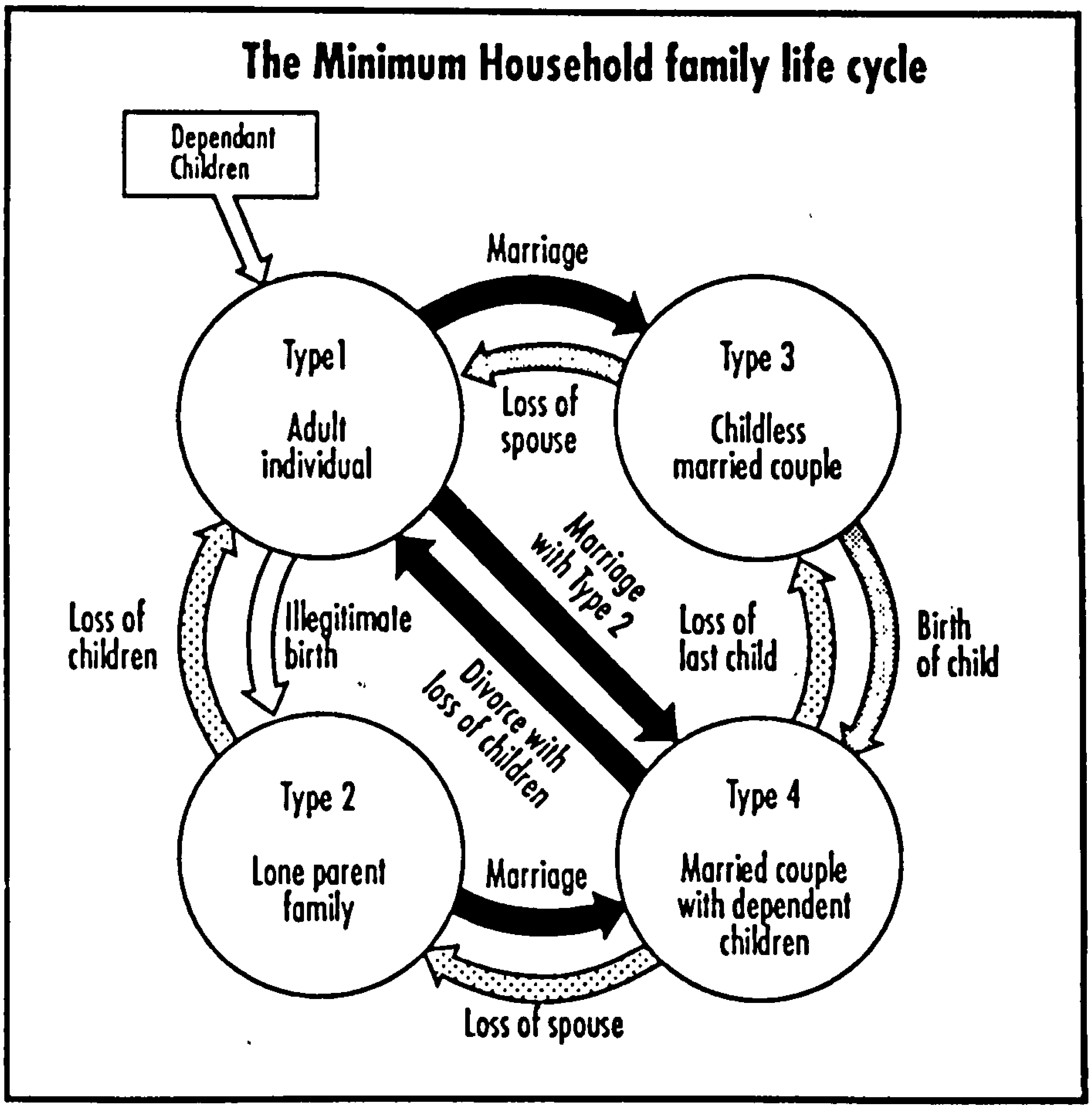
A housing buyer can be defined as a household who is searching for a dwelling in a housing market. A household can be a single person living alone or a group of people living together. It '*combines the time of its members and purchased goods and services into the production of "output", at least some of which are shared among its members. Examples of these outputs are shelter, meals, home entertainment.*' (Ermisch 1990, Page 1)

The decision to buy or not to buy a dwelling is influenced by a household's social and economic background, but primarily via income and demographic composition. Buying or not buying a dwelling is a decision of the household as a whole. For this reason, it is necessary to analyse the possible compositions of households.

The definition of the Minimal Household Unit (MHU) is given by Ermisch and Overton (1985) for the analysis of household formation. The MHUs are defined as the smallest divisible, familial elements within households. It can be regarded as a unit of economic decision-making. In other words the unit is able to attempt to maximise benefits from a given set of alternatives.

There are four types of MHUs: type1-Adult individual; type2-Lone parent families (single parent families); type3-Childless married couples; type4-Married couples with dependent children.

Diagram III(3)



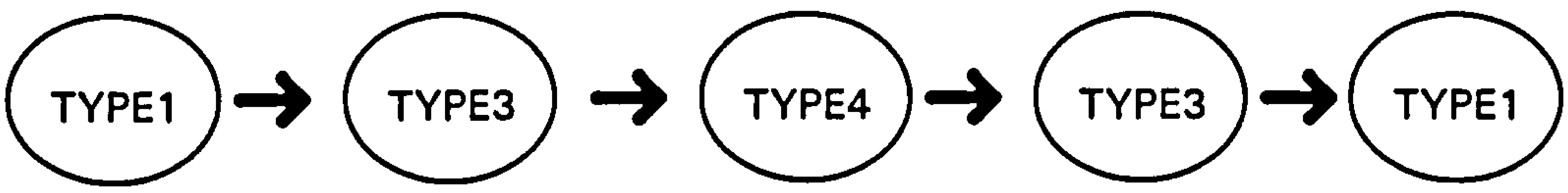
Source: Ermisch, J. F. and E. Overton (1985) Minimal Household Units: A New Approach to the Analysis of Household Formation, Population Studies. 39: 33-54

'An MHU is the smallest group of persons within a household that can be considered to constitute a demographically definable entity. It is definable in purely demographic terms in the sense that an individual, over his lifetime, moves from one type of unit to another by means of a simple demographic transition or event'. (Ermisch & Overton 1985, Page 5)

A household includes one unit or a combination of several of the MHUs. Its housing choice behaviour is influenced by the types of the MHUs and the life cycle of the MHUs. The demographic transitions of a household over its lifetime can be represented as follows:

The arrows in the diagram show the possible transition process between the MHUs.

Based on this diagram, a traditional stream of the family life cycle can be presented as follows:



The life cycle process in the above is that a single young person is separated from his/her parents and forms a new household (Type 1). This household is transferred into the second stage of the life cycle by marriage (Type 3). After the birth of their first child, the household is in the third stage of the life cycle (Type 4). When the children have grown up, they will leave the home, the household will be back to type3. The final stage will be the one person family if one of the couple dies (Type 1).

This traditional stream has been undergoing dramatic changes during recent years in industrialised countries. *'Marriage and motherhood are occurring later, and there is increasing cohabitation without legal marriage, more divorce and one parent families, lower birth rate and a growing proportion of women in paid employment'.* (Ermisch 1981, Page 353)

In fact, different households may follow a different life cycle. Diagram III(3) shows that a household can be initially formed in any type of the four MHUs and then is transferred to the next stage of its life-cycle through the transition from one MHU to another, e.g. the birth of the first child; or through the combination of the different MHUs, e.g. two single households are united by a marriage; or through the separation of the MHU, e.g. divorce.

Although a household's income and its expenditure on housing vary from one to another, some households may have the same demographic composition. The latter allows us to classify the buyers in terms of their demographic compositions, the MHU system provides a useful foundation of grouping the households in terms of their demographic compositions. This is because:

1. the MHU is defined by demographic variables and therefore provides a useful framework to construct the family life cycle which has been recognised as an important factor influencing household housing choice behaviour;

2. the MHU is also defined as an economic decision making unit. A housing buyer or seller can be one of the MHUs in a household although the decision is influenced by all the MHUs in a household.

There is a slight revision here of Ermisch and Overton's MHU system in that type3 MHU of 'childless married couple' is revised to indicate both married couples without children and long term partners since many long term partners are joint housing buyers.

In this study, households are grouped into four 'stages' based on the theory of MHUs. The first stage are single young person households. The census data between 1981 and 1991 has shown that the number of one person households has been increasing dramatically. For example, in Lothian Region, the percentage of single person households has increased from 23.5% (in 1981) to 29.2% (in 1991). As these people are generally economic active, they provide an important source of owner-occupier housing demand. Their demand is significantly different from the other households, e.g they may prefer smaller size dwelling. The second stage is households of young married couple or long term partners. The third stage is households with dependent children. Single parent households are grouped into this category although the survey results (Chapter VI) have shown that this group of households is not active in owner-occupier housing market as most of them are low income households. If the income is fixed, the preference of a single parent household in choosing a dwelling is expected to be similar with that of the other households with dependent children, for example, the demand for good school quality or the dwelling size. As a consequence, they are grouped into the third stage life-cycle. The fourth stage is older single households or older couple households. For most households, this is the end of the life cycle. The decision to buy a dwelling is not only influenced by income, but also by their life savings, especially for retired people.

A housing buyer faces two important constraints when entering the housing market. First, he/she has imperfect housing market information when entering the market, and second, different housing buyers may have different market information levels.

In section 3.2., it was shown that the dwellings in a housing market are unmoveable and both spatially as well as sectorally distributed, and as a result, a buyer may only have partial (imperfect) information about the market when entering it.

To understand the second constraint, it is necessary to analyse the sources of the housing buyers in a market.

Generally housing buyers come from three sources: inter-regional migration, intra-regional migration and new household formation. Any changes in the socio-economic factors which may influence the above three migration flows will affect the demand in a regional owner-occupier housing market.

Inter-regional migration is assumed to be a long distance, employment-related migration. It happens when households move from one region to another region and the migration involves both job change and housing location change. After entering a regional housing market, this group of people will distribute themselves into the public rental housing market, the private rental housing market and the owner-occupier housing market separately.

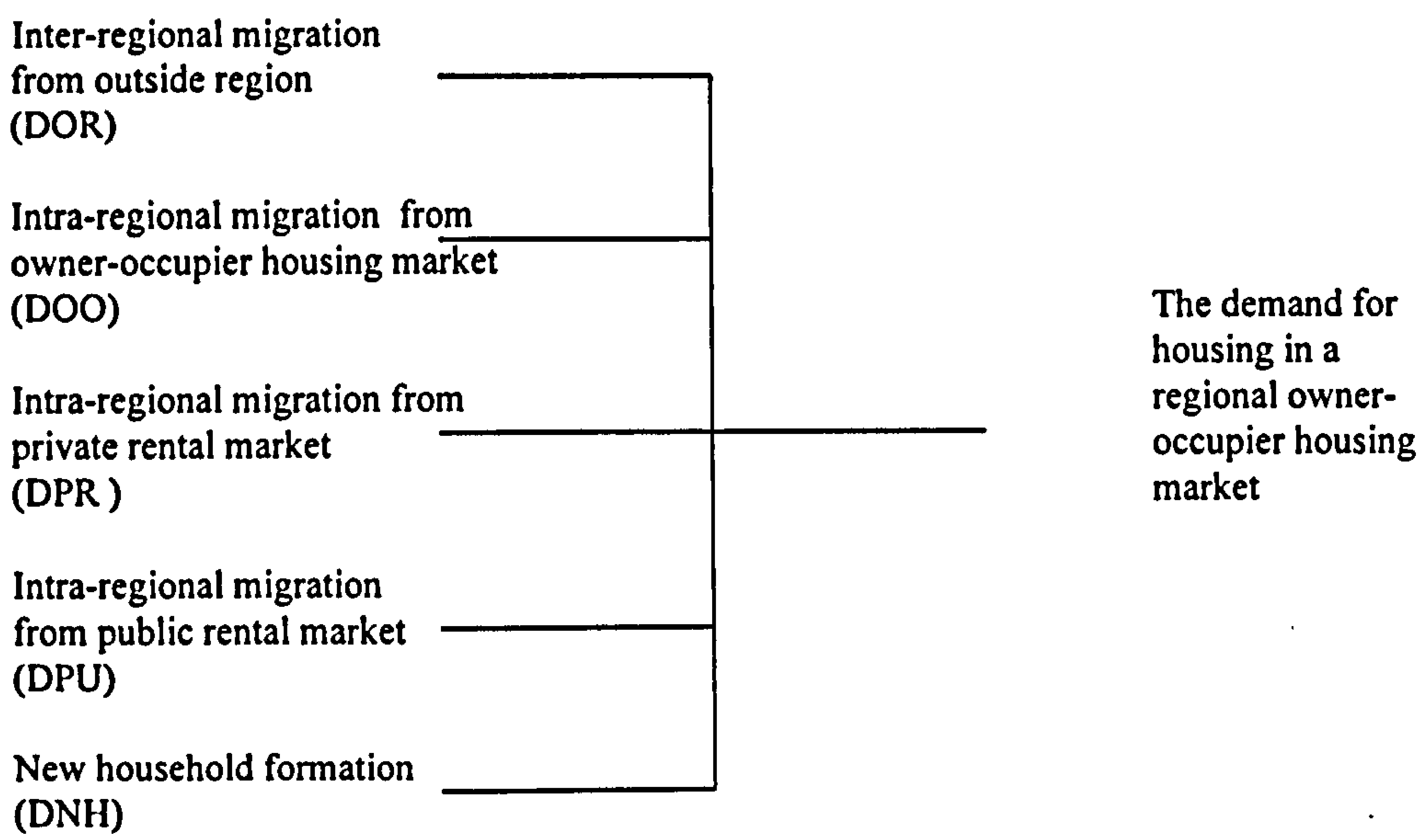
Intra-regional migration is assumed to be a housing-related migration. It happens when households move from one dwelling to another one within the region. In most cases, such migration only involves housing location change. The migration involves a series of turnovers, e.g. from the public or private rental housing market to the owner-occupier housing market or from the owner-occupier housing market to the private or public rental housing market.

New household formation is the third important source of regional owner -occupier housing demand. As discussed above, new households can be formed in any type of the MHUs, e.g. newly married young couples, or newly divorced middle aged people with or without dependent children. Unlike the above two sources, new household formation will certainly add new demand to the housing market.

However in practice the distinction between the three demand groups is unlikely to be clear-cut. Particularly within a dynamic context, the migrants may initially move for housing related reasons then later change their jobs as they become familiar with opportunities existing in their new neighbourhoods or the migrants may be newly formed households, but simultaneously joining the inter-regional migration. For example, some young couples may get married in their home town, but will settle down in another town as a job related migration. In other words, there are overlaps to some extent among these groups. The interaction between the migration groups and the regional owner-occupier housing market can be expressed as below:

Diagram III(4)

The Sources of Regional Owner Occupier Housing Demand



Thus, regional owner-occupier total housing demand (THD) comes from five sources: THD=DOR+DOO+DPR+DPU+DNH. Among them the inter-regional migration (DOR), the regional owner-occupier turnovers (DOO) and the regional new household formation (DNH) are the main demand sources.

The household housing survey undertaken for this study in Lothian Region shows that 45% of the total buyers were previous owner-occupiers in the region, 24% were from outside the region and at least 16% of the total were newly formed households. Among all the buyers

67% of households had at least one experience of buying a house. The others were first time buyers.

As the buyers are from different sources and have different experiences of buying a dwelling in the market, their housing market information levels will be different. The newly formed households who were originally living in the region and the households from intra-regional migration have more information about the market than the households who are from inter-regional migration. The first time buyers have less information about the market than the second (or more) time buyers have.

Thus, different buyers have different housing market information levels and the buyers who have less market information generally need a longer search time and face a higher search cost. This combination of imperfect information and differential information levels gives rise to the crucial problem of trade friction in any housing submarket.

3.4 Housing Search, Choice and Trade Friction

The imperfect housing market information and spatially as well as sectorally disaggregate housing supply forces a buyer to undertake extensive housing search before choosing a dwelling. The search cost and search time depend on his/her market information level. Housing submarket trade friction is a direct result of this housing search. In order to understand housing submarket trade friction, we need to understand a buyer's housing search process and the outcome of that process.

3.4.1 Housing Search and Housing Choice Decision Making Process

Housing search is examined as a process from initial 'considering a move' through orientation search (which is a rapid process with the households quickly focusing on particular product types and areas) till a satisfactory dwelling is found. It is an extensive search over areas as well as over different types of dwellings with house price bidding behaviour. Therefore housing search behaviour will influence the submarket house price.

Two examples are given below in order to illuminate the nature of the process.

The first buyer is assumed to be an inter-regional migrant and his/her information on the market is zero or minimum. The second is assumed to be an intra-regional migrant and the reason for moving is that he is not satisfied with his present neighbourhood. As these two buyers have different knowledge about the market, they will have different search processes and search areas. The discussion will be based on Diagrams III(5)&(6), which are constructed on the simplest nested housing submarket structure.

Since the first buyer has no knowledge of this market, his search begins at the neighbourhood level (see Diagram III(5)).

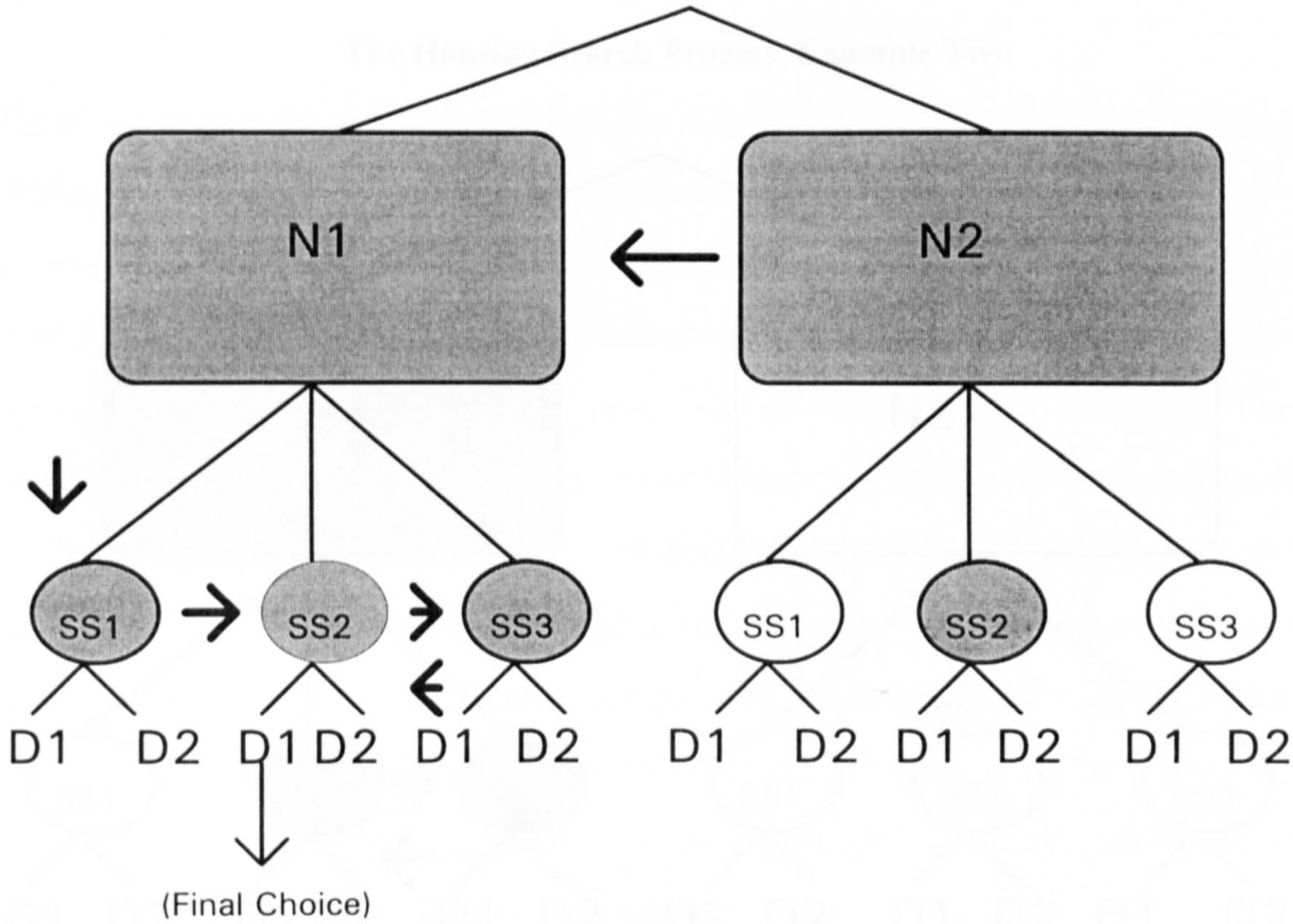
Suppose that he chooses 'N2' first, and searches in 'SS2', but he dislikes the neighbourhood components. He switches the search to 'N1'. After checking the dwellings in 'SS1' of 'N1', he finds the dwellings in this sector are too expensive, and so changes to 'SS2' or 'SS3'.

He keeps switching between these two sectors and investigates the dwellings in each of the sectors until he finds a suitable dwelling. His final choice is assumed to be dwelling 'D1' from 'SS2'. Clearly his choice of a housing sector and the related neighbourhood is a <u>sequential</u> choice process.

His search area and search routine are shown as the shaded boxes and arrows in Diagram III(5).

Diagram III(5)

The Housing Search Process: Example One



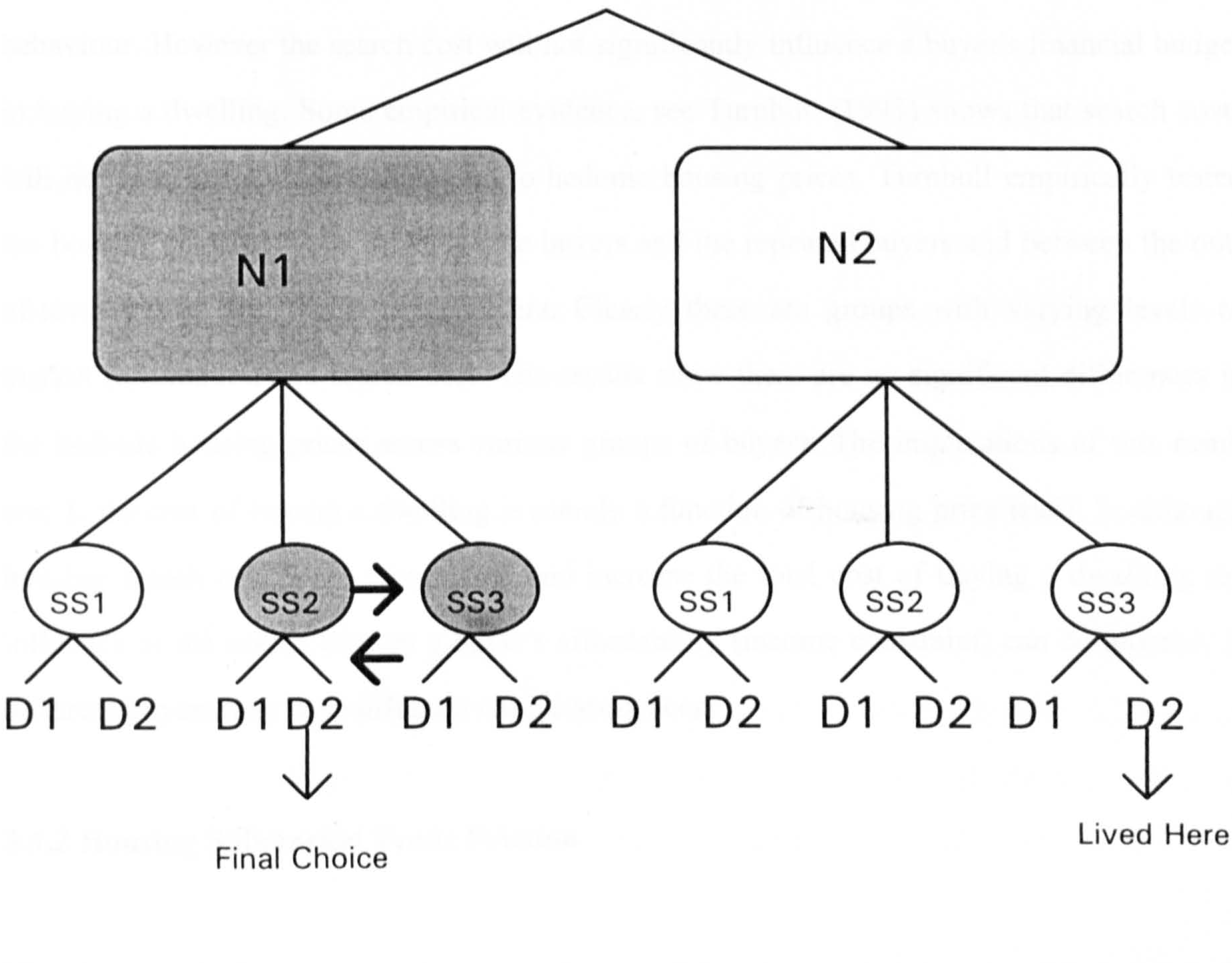
The second buyer is from the intra-regional migration source and is assumed to live in 'SS3' of 'N2' previously. As he doesn't like this neighbourhood, his search starts from 'N1' only.

He also has some pre-knowledge about the market, so he can limit himself to searching in 'SS2' and 'SS3' only. For example he may know that the dwellings in the sector of 'SS1' are too expensive to afford. His search areas and search routine are shown as the shaded boxes and arrows in Diagram III(6). His final choice is assumed to be a dwelling 'D2' from 'SS2'.

Clearly, his choice of a housing sector and the related neighbourhood is a <u>simultaneous</u> choice process.

Diagram III(6)

The Housing Search Process: Example Two



In addition, compared with the second buyer, the first buyer will have a longer search time and his search cost will be higher than the second one although both have chosen dwellings from the same submarket.

Thus different buyers are likely to have different search behaviours. Spatially and sectorally distributed dwellings as well as disaggregate housing demand are the main reasons behind for housing search. Search cost and search time depend on the buyers' information levels on the housing market while search routines depend on the preferences for dwelling components and the possible dwelling components' trade offs. Maclennan (1979b) investigated the furnished rental housing market for students and found that local students had less search cost and less search time than non-local new comers and also their search areas were shaped by their experiences of the market.

Housing choice is the joint result of both the buyer's housing preference and his/her search behaviour. However the search cost will not significantly influence a buyer's financial budget in buying a dwelling. Some empirical evidence, see Turnbull (1993) shows that search costs will not significantly add differences to hedonic housing prices. Turnbull empirically tested the housing costs between the first time buyers and the repeated buyers and between the out-of-town buyers and the in-town buyers. Clearly these are groups with varying levels of market information and search cost. The results show there are no significant differences in the hedonic housing prices across various groups of buyers. The implications of this result are: 1. the cost of buying a dwelling is mainly a function of housing price itself; 2. although housing search may incur search cost and increase the total cost of buying a dwelling, the influence of the search cost on a buyer's affordability (income constraint) can be ignored; 3. different buyers may have different choice sequences.

3.4.2 Housing Submarket Trade Friction

The above analysis exposes an important feature of housing market: housing submarket trade friction.

In the cases illustrated above, although both buyers only chose dwellings from 'SS2' of 'N1', they had been bringing their demands to 'SS1', 'SS2', 'SS3' of the same neighbourhood and to

'SS2' of 'N2' when they undertook housing search in those submarkets. Their search behaviour not only brings demand to the submarket, but also influences the house price there because of their bidding behaviour. Undertaking housing search but not buying a dwelling in a submarket results in housing submarket trade friction. The phenomenon of housing submarket trade friction is, at any time, only a fraction of the short side of the housing demands and supplies being transacted in each housing submarket. Different housing submarkets may have different levels of trade friction. The definition of housing submarket trade friction is given below. Its properties and determinants are discussed.

Two examples are presented here to illustrate the essence of housing submarket trade friction. In the examples, we use 'N1-SS1' to represent the sectoral submarket 'SS1' in the neighbourhood submarket 'N1', and 'N1-SS2' to represent the sectoral submarket 'SS2' in the neighbourhood submarket 'N1'.

In the first example, it is assumed that, at time t, there are 's_1' number of dwellings on sale in 'N1-SS1' and 'd_1' (assuming that, the short side is 'd1', 's_1'>'d_1') number of buyers searching in this submarket. In a unit time interval, there are 'T_1' number of dwellings transacted. Provided the time unit is short enough for no new buyers or sellers to join the market, $T_1 \leq \min(s_1, d_1)$.

If 'T_1'<'d_1', the surplus demand represents that some buyers have searched and then left although there existed surplus supply in the submarket. This indicates the submarket has 'trade friction'. If 'T_1'='d_1', then the submarket has no 'trade friction' at this point in time.

In the second example, suppose that, at time t, there are 's_2' number of dwellings on sale in 'N1-SS2' and 'd_2' (assuming that, the short side is 's1', 's_2'<'d_2') number of buyers searching in this submarket. After a unit time, there are 'T_2' number of dwellings transacted, clearly 'T_2'$\leq \min(s_2, d_2)$.

If 'T_2<'s_2', the surplus supply shows that some sellers did not sell their dwellings successfully even though there was the surplus demand in the submarket. Clearly, this submarket has 'trade friction'. If ' T_2'='s_2', then the submarket has no 'trade friction' at this point in time.

Clearly, the definition of T implies that $q = \frac{s}{T}$ is a measure of the sellers' waiting time in this housing submarket. Further discussion about it will be given in Chapter IV.

However, when we say that the submarket has no trade friction, it doesn't follow that the buyers have perfect knowledge of the submarket. It only implies that the dwelling related components in that submarket suit the buyers' dwelling preferences. Suppose that the buyers' housing market information levels are fixed in the short run. This means that each buyer's search routine is unchanged. If trade friction in one submarket is higher than that of the other, it will often be due to dwelling related components in the other submarket being more suitable to the tastes of the buyers. Therefore, in the short run, submarket trade friction is determined by the degree of the match between the dwelling related components in the submarket and the preference of the buyers for this submarket.

From the analysis above, an equation is suggested for measuring housing submarket trade friction:

$$TF_i = \frac{Min(d_i, s_i)}{T_i} \qquad TF_i \geq 1. \qquad (1)$$

here i denotes the submarket i and TF represents the submarket trade friction.

The larger the value of TF_i is, the higher the submarket trade friction will be. If all the buyers have perfect market information, therefore, they can immediately know in which submarket and which dwelling suits their taste, then in all the submarkets, TF_i=1. In this case the housing submarkets have no trade friction.

If in one housing submarket, $TFi \rightarrow +\infty$, then no trade occurs in the submarket. This doesn't mean that the buyers have little information about the submarket, but it implies that people don't prefer the dwellings in the submarket; if $TFi \rightarrow 1$, it means that the dwellings in this submarket are very preferred by the buyers or it means that this submarket is well-known by the buyers.

If we assume that, the quality of the dwelling related components in a housing submarket, the buyers' housing preference and their market information level remain unchanged in the short run, then the submarket trade friction will be a constant. Any change of these factors in the long run will change the submarket trade friction.

Chapter IV will discuss how housing submarket trade friction influences housing submarket equilibrium price and Chapters V and VII will discuss how housing submarket trade friction influences housing choice behaviour.

CHAPTER IV THE HOUSING SUBMARKET OPERATIONAL SYSTEM AND ITS PROPERTIES

4.1 Introduction

Chapter IV will discuss the nature of regional housing submarket equilibrium and disequilibrium, and the dynamic process via which equilibrium is achieved. The discussion is based on the nested housing submarket structure defined in Chapter III.

One of the main arguments of Chapter III is that a local housing market consists of the disaggregated housing demands and the disaggregated housing supplies. As a result the market *operational* process is a *matching* process between the housing demand and the housing supply. Each buyer must search to find an appropriate dwelling. This gives rise to housing submarket trade friction as discussed in Chapter III.

Given this argument, can such a matching process generate equilibrium and will this equilibrium be stable? Given housing submarket trade friction, the conventional equilibrium approach which assumes frictionless trade is not suitable to the housing market situation. A relatively new equilibrium approach, the 'Dynamic Stock Flow Model with Trade Friction' developed by Weibull (1983, 1984), and Wheaton (1990), is extended and applied to analyse the local nested housing submarket system defined in Chapter III.

The analysis proceeds as follows: 1. setting up a theoretical framework to describe the operational matching process of a regional nested housing submarket system (see Section 4.2); 2. simulating the system using a revised dynamic stock-flow model with trade friction (see Section 4.3); 3. analysing the static properties of housing submarket equilibrium (see Section 4.4); 4. simulating the system equilibrium stability, and analysing the dynamic disequilibrium properties of housing submarket (see Section 4.5).

4.2 The Housing Submarket Operational System

4.2.1 The System: a Matching Framework

In Diagram I(1) of Chapter I, the round box represents a matching process between the disaggregate housing demands and housing supplies. Understanding this matching process is the key to understanding housing submarket operations. The following diagrams (Diagrams IV(1)&(2)) specify this matching process based on a simple nested housing submarket structure, in which there are two neighbourhood housing submarkets, within each there are two sectoral housing submarkets.

Diagram IV(1)

Housing Submarket Operational System: a matching framework (1)

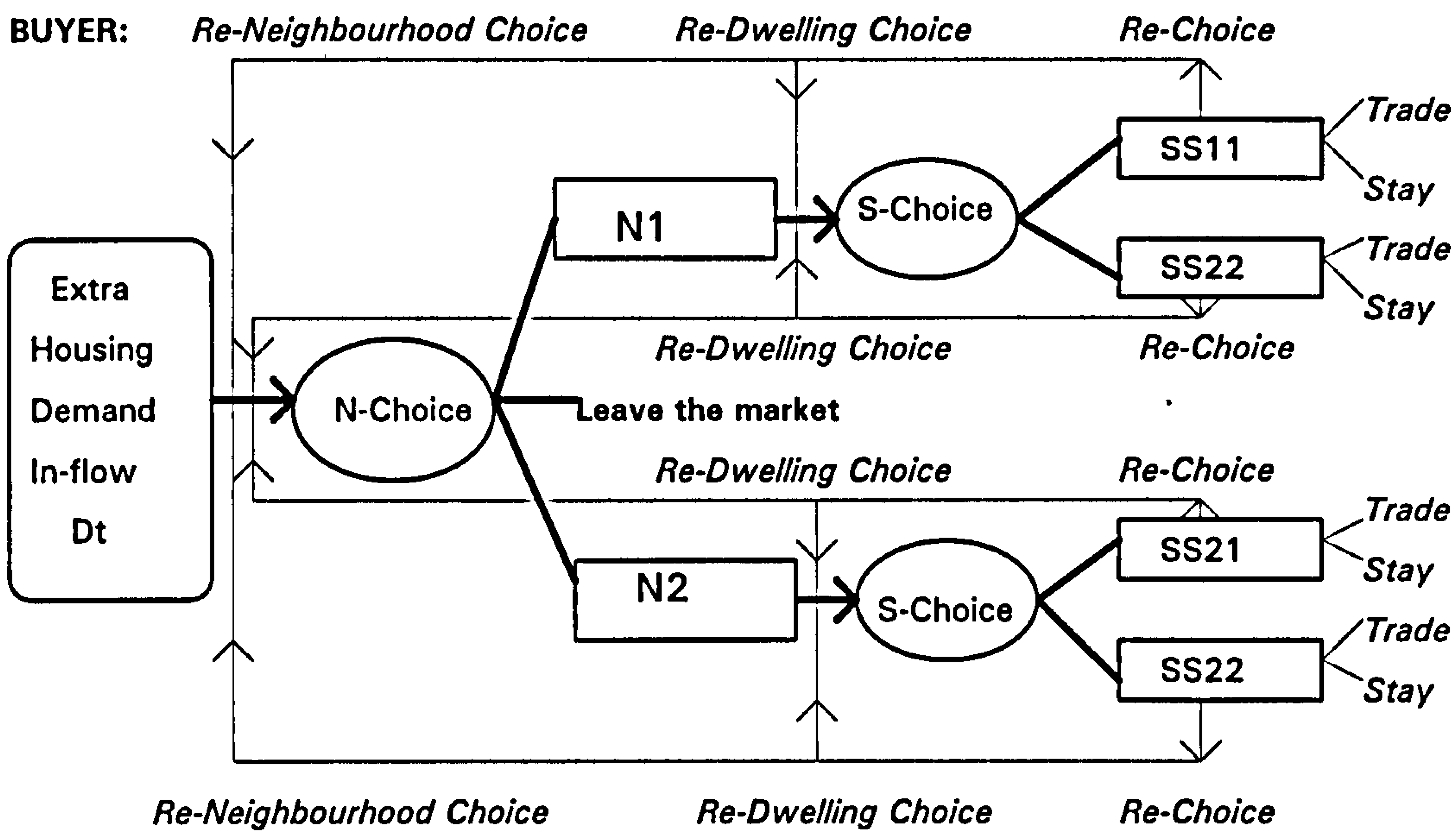
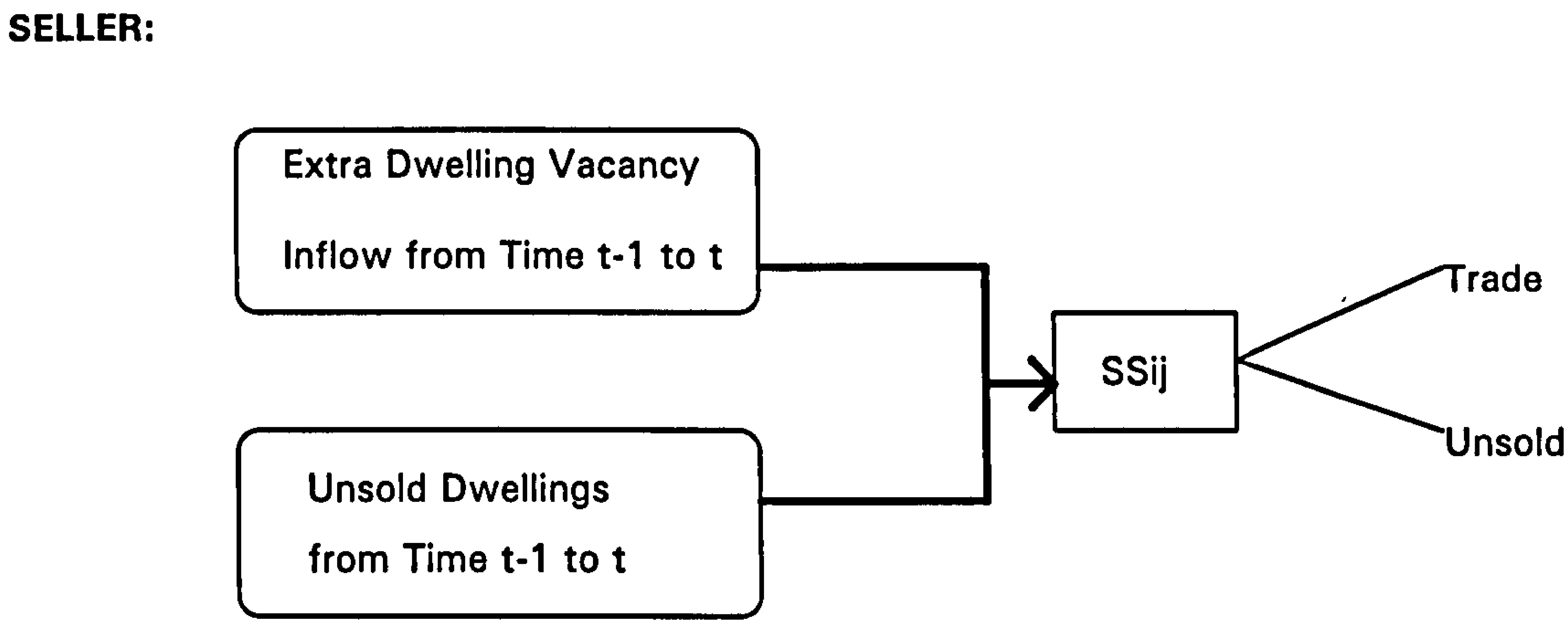


Diagram IV(2)

Housing Submarket Operational System: a matching framework (2)



Where: i,j=1,2

Diagrams IV(1)&(2) represent a dynamic operational process in a regional owner-occupier housing market.

For the buyers: in Diagram IV(1), the round boxes represent the buyers' search and choice decisions and the square boxes represent the housing submarkets. ‘N-choice’ and ’S-choice’ represent the distributional process of the buyers to the different neighbourhood housing submarkets and the different sectoral housing submarkets.

The thick lines show the search routes of the buyers distributed into the different housing submarkets and the hair lines are the routes of the buyers joining the re-choice process.

D_t is the extra housing demand in-flow to the market at time t. The sources of Dt were discussed in Section 3.3.

'Trade' represents the number of dwellings traded within a specific time unit (See Section 3.4) and 'Stay' represents the number of buyers who keep searching in the same housing submarket and transfer their demands to the next time unit in the same submarket. The re-choice flow contains buyers who leave the housing submarket and will be re-distributed among the other housing submarkets. There is a possibility that these buyers will go back to the same housing submarket.

For the sellers: in Diagram IV(2), the total housing supply comes from the dwelling vacancies and the unsold dwellings from the last time period, and then, they have two possible outcomes: some are traded (‘Trade’); some are not traded (‘Unsold’) and will be transferred to the next period.

The dynamic matching process between the buyers and the sellers is described in 4 steps:

1. At time t, a group of buyers enter the regional owner-occupier housing market (D_t). This in-flow joins the re-neighbourhood choice flows which are the housing demands transferred from the last time period and forms the total demand in-flow to the neighbourhood housing submarkets.

2. The first action of these buyers is to make a neighbourhood choice. They face three choices at this stage: to enter neighbourhood housing submarket 'N_1'; to enter neighbourhood submarket 'N_2' or to leave the owner-occupier housing market. Housing demand is thus distributed into different neighbourhood housing submarkets in relation to the buyers' preferences for each housing submarket.

3. After being distributed into the neighbourhood housing submarkets, the buyers form an extra demand in-flow in each of the neighbourhoods. This in-flow joins the re-dwelling choice flows which are transferred from the last time period and forms the total demand in-flow to the sectoral housing submarkets nested in the neighbourhood. These buyers are distributed into the sectoral housing submarkets in relation to their preferences for the dwellings in the sectoral housing submarket.

4. The buyers who enter a sectoral housing submarket, are merged with the buyers who are transferred from the last time period in the submarket and form the total housing demand for this sectoral submarket. On the other side, the new dwelling vacancies together with the sellers who didn't sell their dwelling in the last time period form the total housing supply for this submarket. Therefore, a matching process between the buyers and the sellers in this submarket starts. The total housing demand described above has three possible outcomes. Some find the dwellings which they want and

transactions are undertaken ('Trade'); some leave the submarket and join the re-choice flows ('Re-choice'); the others decide to keep searching in the same submarket ('Stay').

The above discussion describes a general matching process between the buyers and the sellers. Two points related to this process are stressed below.

1. The model allows that different buyers follow different search routines. For example, a buyer, who was living in the submarket 'N_1-SS_1' and wanted to change a dwelling, will join the re-choice flow first, then enter one of the housing submarkets.

2. The buyers' housing market information level improves during the search, and hence, their housing preference may be altered. In other words, their probabilities of entering different housing submarkets changes during the search. This probability is named as search probability which is a function of their housing market information level as well as their housing preference. The probability estimated without considering the buyers' information level, is named as choice probability.

The above discussion shows the complexity of mathematically modelling the matching process. Therefore, some assumptions are deemed necessary.

4.2.2. Some Assumptions about the System

Assumption 1

The housing market is a pure owner occupier housing market. This means there are no housing price controls, and the housing price change is only influenced by housing demand and supply in each submarket.

Assumption 2

The housing market is in a stable socio-economic environment in the short-run. 1. There are no changes in the regional wage rate, unemployment rate or the relative wage rates or unemployment rates between the regions. 2. There is no change in regional demographic structure. As a result, the extra demand inflow to the owner-occupier housing market is a fixed flow. The subscript 't' can be dropped from 'D_t'.

Assumption 3

The discussion focuses on the short run during which the new additions to or deletions from a housing market can be ignored. The total housing stock in each housing submarket is unchanged. The only supply channel is via vacancies. It is also assumed that the vacancy rate is constant in only the short run period. This implies that the housing market is demand oriented.

Assumption 4

On the supply side, within each sectoral housing submarket, differences in the dwelling prices and the dwelling components (non-key) are ignored. The choice for a dwelling is simply assumed as the choice for a sectoral housing submarket.

Assumption 5

On the demand side, the buyers are distributed into different housing submarkets by their search or choice probabilities. Since the housing market information level can not be measured, we are forced to use the choice probability model as an approximation to the search probability model. The choice probability model to be used in the mathematical model is discussed in Section 4.3 to describe housing search behaviour. In this model, all buyers are assumed to face the same choice set and have the same housing preference, which implies that the coefficients in the probability model are the same between the buyers in the short run.

4.3 An Extended Dynamic Stock-Flow Model with Trade Friction

The approach of a dynamic stock-flow model with trade friction was introduced in Chapter II. This is developed based on the work of Weibull (1983,1984) and his earlier joint study on the functioning of markets under conditions of chronic shortage, (Kornal & Weibull(1978)) which was to a large extent inspired by the comprehensive discussion in Kornal (1980); in particular, the present treatment of market trade friction can be seen as a direct formalization of Kornai's ideas. In this chapter, the approach is extended to a nested housing submarket system. The econometric model discussed below is a mathematical specification of the housing market operational system (see Diagrams IV(1)&(2)).

The dynamic analysis will be conducted in terms of discrete time t, where t is an integer, $0 \leq t < +\infty$. The relevant time interval T, including t=0, is an interval between $[0, +\infty)$. The dynamic analysis can also be discussed in terms of continuous time (Weibull 1983), but in terms of housing market, discrete time is more realistic as the real housing information, i.e. dwelling price or dwelling transaction, is usually produced by month, quarter or year. Another advantage is that using discrete time can make the discussion in this section to be consistent with the computer simulation in Section 4.5.

Each time period, from t-1 to t, represents one unit time interval during which some dwellings are traded and housing submarket prices undergo some adjustments. It should be emphasised that this time unit is different from a buyer's search time. It only means a time period during which, in each housing submarket, some demand and supply can be transacted and the housing price change signals can be fed back to the buyers and the sellers through the housing agencies (e.g. estate agencies or solicitors). It can be one week or one month, and depends on the system of housing agencies. However the search time is related to a specific buyer's (sellers') time in a market. Some empirical evidence on the seller's waiting time in a market is given in Hughes & Sirmans (1992), who reports that the time a dwelling is on the market is about 100 days on average.

The current state of a housing market at time $t \in T$ is a set of points in a three dimensional state space, which can be defined as:

$$\Gamma^k = R_+^k \otimes R_+^k \otimes R_{++}^k \qquad (1)$$

where, k is the number of submarkets in a housing market; R+ is the non-negative real axis and R++ is the positive real axis. Each point describes one housing submarket using three variables, housing demand, housing supply, which values change between [0, +∞) described by non-negative real axis; and housing price, which value changes between (0, +∞) described by positive real axis.

For example, if k=1, it means that it is unitary market. The dwellings are homogeneous with one housing price prevailing. The current market state is one point X(t) in Γ^1:

$$X(t) = \begin{bmatrix} d(t) & s(t) & p(t) \end{bmatrix}$$

where, d(t) is the current effective housing demand, s(t) is the current effective housing supply and p(t) is the current housing price. Here the 'effective demand' means all the buyers who are engaged in a search and the 'effective supply' means all the dwellings which are on sale in each housing submarket. In other words, the current effective housing demand (supply) is the number of dwelling units that the aggregate of housing buyers (sellers) is willing to buy (sell) at time t. We also assume the current housing price represents all the expenditures in buying a dwelling. This is because, in reality, buying a dwelling entails a number of expenditures, i.e. search cost, legal fee or insurance. But, compared with the house price, these expenditures are not significant.

In the case of the nested housing submarket structure shown in Diagram IV(1), totally there are six housing submarkets: two neighbourhood housing submarkets, two and four sectoral housing submarkets with each two nested in one neighbourhood. The current state of the housing market can be represented by a group of six points in the state space Γ^6, these six points are $x_1(t)$, $x_2(t)$, $x_{11}(t)$, $x_{12}(t)$, $x_{21}(t)$ and $x_{22}(t)$. The market situation at time t can be represented by the matrix X(t).

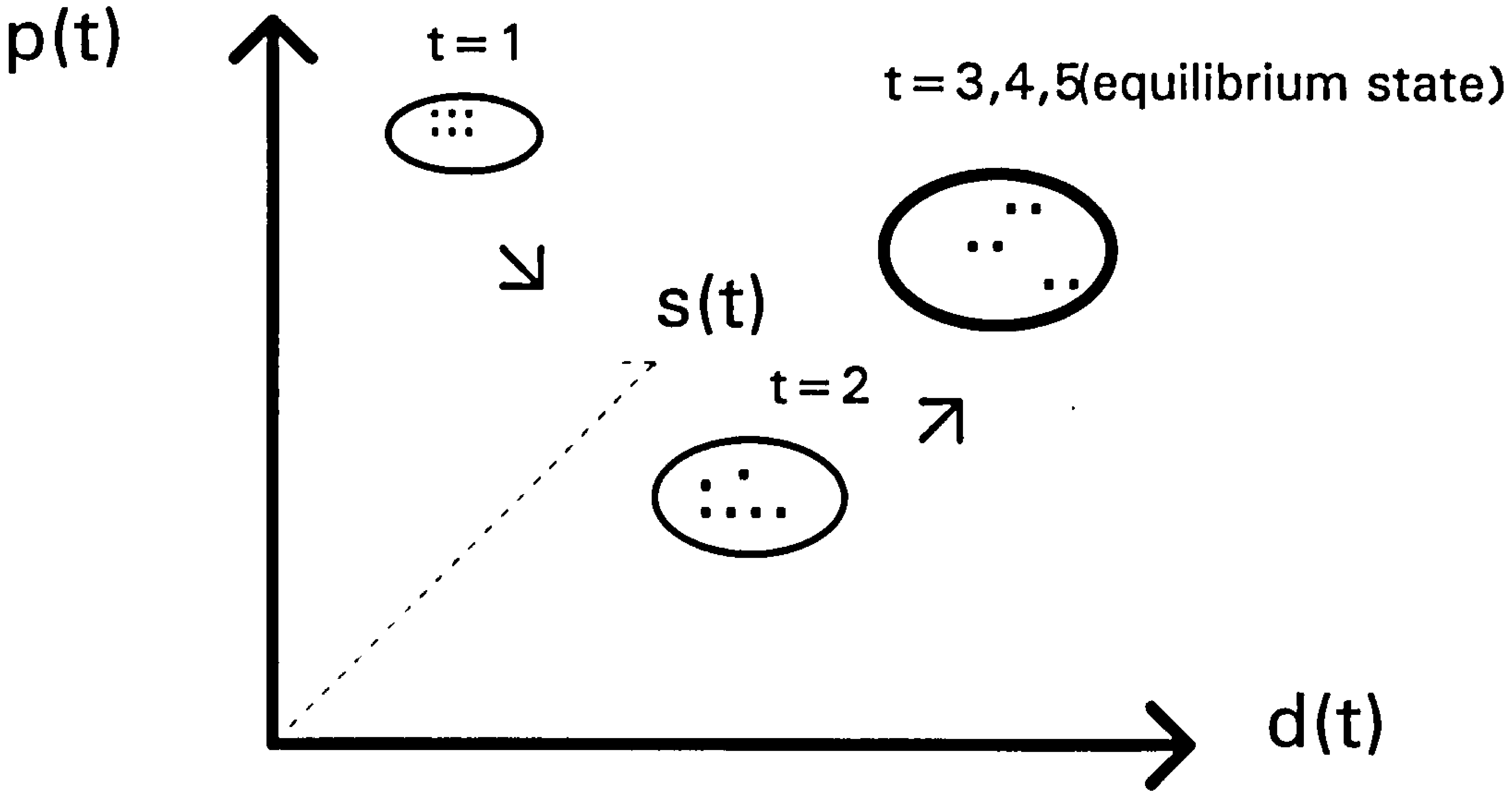
$$X(t)=\begin{bmatrix} x_1(t) \\ x_2(t) \\ x_{11}(t) \\ x_{12}(t) \\ x_{21}(t) \\ x_{22}(t) \end{bmatrix} = \begin{bmatrix} d_1(t) & s_1(t) & p_1(t) \\ d_2(t) & s_2(t) & p_2(t) \\ d_{11}(t) & s_{11}(t) & p_{11}(t) \\ d_{12}(t) & s_{12}(t) & p_{12}(t) \\ d_{21}(t) & s_{21}(t) & p_{21}(t) \\ d_{22}(t) & s_{22}(t) & p_{22}(t) \end{bmatrix} \qquad (2)$$

where, $x_i(t)$, i=1,2, is the situation of neighbourhood housing submarket, N;
$x_{ij}(t)$ i,j=1,2, is the situation of sectoral housing submarket, SS_{ij} nested in neighbourhood housing submarket, N_i.

The dynamic process of this housing submarket structure is presented by Diagram IV(3).

Diagram IV(3)

Three Dimensional State Space (Γ^6)



In this diagram, each circle contains six points, each point representing the situation of one housing submarket (x(t)), including housing price (p(t)), housing demand (d(t)) and housing supply (s(t)) in the submarket. Six points in each circle together represent the situation of a nested housing submarket structure (X(t)).

The dynamic pathway is: from t=1 to t=3, the housing demand, supply and housing price in each housing submarket are changing and the market position in this state space is moving, which is shown as arrows. At t=3, the housing market achieves an equilibrium position which means that, after t=3 onwards, the housing demand, supply and housing price keep still in each submarket.

As discussed in Section 4.2.1., housing demands are distributed into the different housing submarkets through the search probability 'channel'. This search probability is approximated by the choice probability (see Assumption 4 in Section 4.2.2).

In a nested housing submarket structure, it is assumed that the probabilities of a buyer choosing different housing submarkets can be calibrated using the nested logit model (a detailed discussion is given in Chapter VI). A brief summary of the model is given below.

According to Assumption 5 in Section 4.2.2, the buyers have the same housing preference, therefore, the subscript denoting an individual buyer can be dropped from equations (3)-(6) below, which makes the discussion simple.

$$\Pr_{j/i}(t) = \frac{\exp(\alpha_1 * p_{ij}(t)) + \alpha_2 * q_{ij}(t) + \alpha_3 * X_{ij})}{\sum_j \exp(\alpha_1 * p_{ij}(t) + \alpha_2 * q_{ij}(t) + \alpha_3 * X_{ij})} \tag{3}$$

$$\Pr_i(t) = \frac{\exp(\lambda * Y_i + (1-\sigma) I_i)}{\sum_i \exp(\lambda * Y_i + (1-\sigma) I_i) + 1} \tag{4}$$

$$\Pr_0(t) = \frac{1}{\sum_i \exp(\lambda * Y_i + (1-\sigma) I_i) + 1} \tag{5}$$

$$I_i = \ln(\sum_j \exp(\alpha_1 * p_{ij}(t) + \alpha_2 * q_{ij}(t) + \alpha_3 * X_{ij})) \tag{6}$$

where, 1. $\Pr_i$ (t) is the marginal probability of choosing neighbourhood N_i at time t, and $\Pr_0$ (t) is the probability of leaving the housing market at time t, (in the case of Diagram IV(1), i=1 or 2); $\Pr_{j/i}$ (t) is the conditional probability of choosing the j^{th} sectoral housing submarket nested in the i^{th} neighbourhood housing submarket at time t, (in the case of Diagram IV(1), j=1 or 2). $\Pr_{ij}$ (t) is the probability of choosing the ij^{th} sectoral housing submarket at time t, where:

$$\Pr_{ij}(t) = \Pr_i(t) * \Pr_{j/i}(t)$$

2. I_i is the 'inclusive value'. This summarises all the dwelling information in the i^{th} neighbourhood. The coefficient of the inclusive value $1-\sigma$, $0<\sigma\leq1$ allows a test of the IIA axiom, and when $1-\sigma=1$, equations (3) to (6) reduce to the traditional multinominal logit model (see Chapter VI).

3. X_{ij} is the dwelling components of the j^{th} sectoral housing submarket nested in the i^{th} neighbourhood submarket and Y_i is the neighbourhood components of the i^{th} neighbourhood. In the short run, they are assumed to be the constants.

4. p_{ij} is the dwelling price of the j^{th} sectoral housing submarket nested in the i^{th} neighbourhood submarket and q_{ij} is the seller's waiting time in this submarket (See the discussion in Section 3.4.2 and equations (7-1)&(7-1) in this section).

The importance of including q_{ij} in the model are discussed below.

Buying a house has dual roles: as a consumption good and as an investment good. Housing's role as an investment good requires that a buyer has to deal with uncertainty and forms expectations regarding future house prices. The prices of housing submarkets are not only different, but also expected to have different changing rates. For example, in Lothian Region, a phenomenon observed in the owner occupier housing market is that the price of Lothian Villa is increasing faster than the price of Lothian Terraced Villa in the past few years (see Diagram 1 in Appendix 7-2). This implies that the future housing price changes may be different between the different regional housing submarkets. The uncertainty and expectations for the future submarket housing prices, therefore play a crucial role in housing choice behaviour.

Empirically, this expectation is assumed to be measured by the current housing sellers' waiting time. A shorter waiting time implies that there is a higher dwelling transaction rate in the submarket. In other words, the housing submarket has a higher marketability. Therefore a buyer has a higher expectation of the future submarket housing price increase.

Referring to equation (3), both the coefficients α_1 and α_2 are therefore negative real numbers.

The sellers' waiting time at time t can be represented by equation (7-1), which is the quotient of the current submarket housing supply and the number of dwellings traded in unit time in the submarket. Replacing $T_{ij}(t)$ by equation (1) in Section 3.4.2, equation (7-1) is extended as:

$$q_{ij}(t)=\frac{s_{ij}(t)}{T_{ij}(t)}=\frac{s_{ij}(t)}{\dfrac{\min(d_{ij}(t),s_{ij}(t))}{TF_{ij}(t)}}=\frac{s_{ij}(t)}{\beta_{ij}(t)*\min(d_{ij}(t),s_{ij}(t))} \qquad (7\text{-}1)$$

$$\beta_{ij}(t)=\frac{1}{TF_{ij}(t)} \qquad (7\text{-}2)$$

$TF_{ij}(t)$ is defined in Section 3.4.2. $\beta_{ij}(t)$ in equation (7-2) is named as submarket dwelling transaction velocity defined as an inverse of the trade friction ($TF_{ij}(t)$) in the ij^{th} sectoral housing submarket (Weibull 1983).

If $d_{ij}(t)$ is bigger than $s_{ij}(t)$, the waiting time is just the inverse of $\beta_{ij}(t)$, which is equal to $TF_{ij}(t)$. This means that a smaller submarket transaction velocity (or a larger housing submarket trade friction) will produce a longer waiting time. If $s_{ij}(t)$ is bigger than $d_{ij}(t)$, then either a shorter demand queue or a longer supply queue will increase a seller's waiting time in that submarket.

Since $T_{ij}(t)\leq S_{ij}(t)$ if $T_{ij}(t)$ (and so $\beta_{ij}(t)$) tends towards zero over time, this means that the housing submarket exhibits no trade, e.g. the dwelling related components are not matched with the buyers' preferences at all. If this happens, the sellers' waiting time $q_{ij}(t)$ will tend towards ∞, which means no sellers can sell their dwelling in this submarket. A realistic phenomenon in an urban housing market is some previously prosperous neighbourhood becomes dumping over time and attracts less and less buyers. Finally the area may have to be demolished as no one would like to buy a dwelling there any more.

If $T_{ij}(t)$ tends towards $\min(s_{ij}(t), d_{ij}(t))$, and so $\beta_{ij}(t)$ tends towards 1 over time, this means that the short-side of the submarket, either demand or supply, can all be traded immediately and the trade friction in this submarket reduces to zero. If this happens, the sellers' average waiting time $q_{ij}(t)$ will either tend towards 1 (if $s_{ij}<d_{ij}$) or tend towards $\frac{s_{ij}}{d_{ij}}$ (if $s_{ij}>d_{ij}$). In the latter case, the sellers' average waiting time is bigger than '1', which means some sellers cannot sell their dwelling immediately because there are not enough buyers.

In the short run, $TF_{ij}(t)$ is assumed as a constant (Section 3.4.2). Therefore t is dropped from $TF_{ij}(t)$ and $\beta_{ij}(t)$.

The dynamic process (See also Section 4.2), from time t to t+1, in a housing market can be mathematically specified as follows. As 't' is defined as discrete time, the sentence, 'from time t to t+1', will represent one time unit which is from the beginning of t to the beginning of t+1. The specification below is an extension or revision of the work of Weibull (1983).

At the ij^{th} sectoral housing submarket:

$$d_{ij}(t)=T_{ij}(t)+RC_{ij}(t)+SD_{ij}(t) \quad (8\text{-}1)$$

$d_{ij}(t+1)=ND_{ij}(t)+SD_{ij}(t)$ (8-2)

$s_{ij}(t)=TS_{ij}(t)+T_{ij}(t)$ (8-3)

$s_{ij}(t+1)=NS_{ij}(t)+TS_{ij}(t)$ (8-4)

At the i^{th} neighbourhood housing submarket:

$d_i(t)=T_i(t)+RC_i(t)+SD_i(t)$ (9-1)

$d_i(t+1)=ND_i(t)+SD_i(t)$ (9-2)

$s_i(t)=TS_i(t)+T_i(t)$ (9-3)

$s_i(t+1)=NS_i(t)+TS_i(t)$ (9-4)

where, from the beginning of t to the beginning of t+1, in the sectoral and neighbourhood housing submarkets separately, where:

T_{ij}, T_i are the number of dwellings traded;

RC_{ij}, RC_i are the number of buyers who join the re-choice flows;

SD_{ij}, SD_i are the number of buyers who keep searching in the same submarket;

ND_{ij}, ND_i are the total addition to the demand side;

NS_{ij} , NS_i are the total addition to the supply side;

TS_{ij}, TS_i are the number of sellers who haven't sold their dwelling.

The dynamic process is given as follows:

$$\frac{\Delta(d_{ij}(t))}{\Delta t} = ND_{ij}(t) - (RC_{ij}(t) + T_{ij}(t)) \qquad (10)$$

$$\frac{\Delta(s_{ij}(t))}{\Delta t} = NS_{ij}(t) - T_{ij}(t) \qquad (11)$$

$$\frac{\Delta(p_{ij}(t))}{\Delta t} = f(d_{ij}(t), s_{ij}(t)) * p_{ij}(t) \qquad (12)$$

$$\frac{\Delta(d_i(t))}{\Delta t} = ND_i(t) - (RC_i(t) + T_i(t)) \qquad (13)$$

$$\frac{\Delta(s_i(t))}{\Delta t} = NS_i(t) - T_i(t) \qquad (14)$$

$$\frac{\Delta(p_i(t))}{\Delta t} = \frac{1}{J}\sum_j f(d_{ij}(t), s_{ij}(t)) p_{ij}(t) \qquad (15)$$

where, $\frac{\Delta(.)}{\Delta t}$ is the difference function, and if assuming that the housing price in a neighbourhood is an average of the housing prices of all the dwelling sectoral submarkets in the neighbourhood, equation (15) is derived from equation (12).

In equation (12), it is assumed that the housing price change in a submarket is endogeneously determined by the balance ($z_{ij}(t)=d_{ij}(t)-s_{ij}(t)$) between the effective demand and the effective supply. A question of both theoretical and practical importance is how the balance z_{ij} is conveyed to those market agents who are ultimately the price setters. In practice, observations of demand queues and dwelling vacancies in a submarket will convey the balance of demand and supply to the dwelling price setters. Theoretically, function 'f' can be assumed as a sign-preserving function, which means if $f(a) \gtreqless 0 \Leftrightarrow a \gtreqless 0$ and 'a' is a real number.

Equations (10)-(12) can be specified further by assuming that:

$$\frac{\Delta(d_{ij}(t))}{\Delta t} = a_{ij}(x(t), t) - b_{ij}(x(t), t) \qquad (16)$$

$$\frac{\Delta(s_{ij}(t))}{\Delta t} = c_{ij}(x(t),t) - b_{ij}(x(t),t) \qquad (17)$$

$$\frac{\Delta(p_{ij}(t))}{\Delta t} = f(d_{ij}(t) - s_{ij}(t)) * p_{ij}(t) \qquad (18)$$

where: $a_{ij}(x,t)$, $b_{ij}(x,t)$, and $c_{ij}(x,t)$ are defined as behavioural functions, which represent the market change rates of demand, trade and supply over time. Equation (18) is the current price formation rate for the ij^{th} submarket (the rate at which the price changes over time). Further specifications of these functions are given below.

In equation (16), $a_{ij}(x(t),t)=ND_{ij}(t)-RC_{ij}(t)$ which is the current net effective demand rate in the ij^{th} sectoral housing submarket (the inflow of new requests minus the outflow of withdrawn requests). It is specified as:

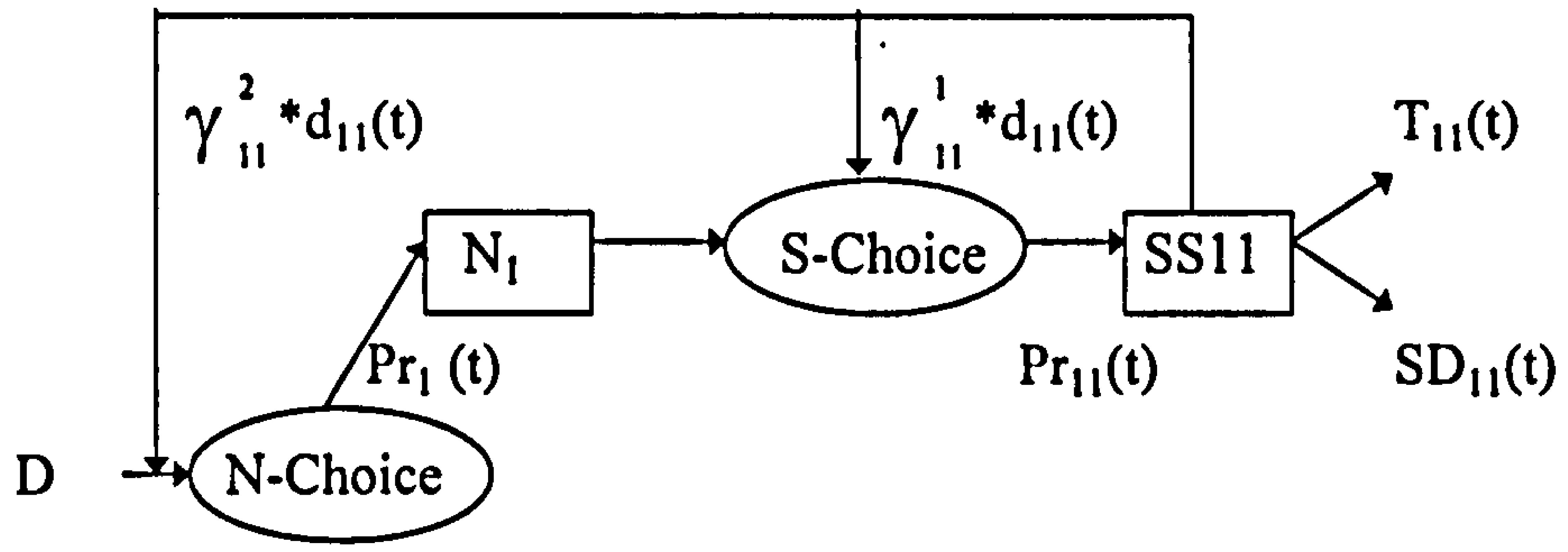
$$a_{ij}(x(t),t) = ((D + \sum_{k,\lambda} \gamma^{2}_{k\lambda} d_{k\lambda}(t)) \Pr_{i}(t) + \sum_{\lambda} \gamma^{1}_{i\lambda} d_{i\lambda}(t)) \Pr_{j/i}(t) - (\gamma^{1}_{ij} + \gamma^{2}_{ij}) d_{ij}(t) \qquad (19)$$

As explained in Assumption 2 (Section 4.2.2), D is time-invariant. The parameter γ^{1}_{ij} is the housing buyers' re-choice rate at the dwelling level, and γ^{2}_{ij} is the housing buyers' re-choice rate at the neighbourhood level. They are assumed to be time invariant constants (See Diagrams IV(1)&(4)).

Diagram IV(4)

An Example of Housing Submarket Operation

From time t to t+1:



$b_{ij}(x(t),t)=T_{ij}(t)$ is the current trade rate in the ijth sectoral housing submarket (number of dwellings traded from t to t+1). According to equation (1) of Chapter III and equation (7-2) of this Chapter, it can be expressed as:

$$b_{ij}(x(t),t) = \beta_{ij} * \min(d_{ij}(t), s_{ij}(t)) \tag{20}$$

In equation (17), $c_{ij}(x(t),t)=NS_{ij}$ is the current net effective supply rate in the ijth sectoral housing submarket (the inflow of additional dwelling units. The withdrawals from sales are assumed to be zero. According to assumption three, it is specified as:

$$c_{ij}(x(t),t) = \varepsilon_{ij}(\delta_{ij} - s_{ij}(t)) \tag{21}$$

where ε_{ij} is the vacancy rate and δ_{ij} is the total housing stock.

From the above definitions, it is clear that $b_{ij}(x(t),t)$ and $c_{ij}(x(t),t)$ are non-negative numbers and $a_{ij}(x(t), t)$ is a real number.

Using the same arguments, equations (13) to (15) can be re-specified as:

$$\frac{\Delta(d_i(t))}{\Delta t} = a_i(x(t),t) - b_i(x(t),t) \tag{22}$$

$$\frac{\Delta(s_i(t))}{\Delta t} = c_i(x(t),t) - b_i(x(t),t) \tag{23}$$

$$\frac{\Delta(p_i(t))}{\Delta t} = \frac{1}{J}\sum_J f_i(d_{ij}(t) - s_{ij}(t))p_{ij}(t) \tag{24}$$

where:

$$a_i(x(t),t) = \sum_J a_{ij}(x(t),t) \tag{25-1}$$

$$bi(x(t),t) = \sum_J b_{ij}(x(t),t) \tag{25-2}$$

$$ci(x(t),t) = \sum_J c_{ij}(x(t),t) \tag{25-3}$$

The above equations (16)-(18) and (22)-(24) represent the dynamic process within a nested housing submarket structure. The dynamic features of this process are discussed below.

First of all, $0 \le \gamma_{ij}^1, \gamma_{ij}^2, and \gamma_{ij}^1 + \gamma_{ij}^2 \le 1$. When $\gamma_{ij}^1 + \gamma_{ij}^2 = 0$, no dwellings join the re-choice flows in that submarket; when $\gamma_{ij}^1 + \gamma_{ij}^2 = 1$, all the buyers in that submarket join the re-choice flows and no trade happens, β_{ij} will be zero. The relation is:

$$0 \le \gamma_{ij}^1 * d_{ij}(t) + \gamma_{ij}^2 * d_{ij}(t) + \beta_{ij} * \min(d_{ij}(t), s_{ij}(t)) \le d_{ij}(t) \tag{28}$$

which denotes that at any time, in each housing submarket, the number of dwellings traded and the number of buyers joining the re-choice flows are less than the total effective housing demand in that submarket.

Second, equations (18) and (24) describe a model of housing submarket price formation. Clearly, the neighbourhood housing submarket price is determined by the sectoral housing submarket prices within it.

Rewriting equation (18) by assuming that the sign reverse function 'f' is a linear function with zero intercept, we get:

$$\frac{\Delta(p_{ij}(t))}{\Delta t} = \chi_{ij} * p_{ij}(t) * (d_{ij}(t) - s_{ij}(t)) \qquad (26)$$

where χ_{ij} is assumed as a constant (non-negative real number). Equation (26) shows that the submarket housing price change within each time unit is positively related to the submarket housing price level as well as the excess housing demand in this submarket. $\chi_{ij}=0$ means that the submarket housing price will not change in response to any excess housing demand, e.g. the submarket housing price is regulated, i.e. under house price control.

If it is assumed that one time unit is equal to 1, $\Delta t = 1$, equation (26) can be written as:

$$p_{ij}(t) = p_{ij}(0) * \prod_{\tau=0}^{t-1} (1 + \chi_{ij} * (d_{ij}(\tau) - s_{ij}(\tau))) \qquad (27)$$

Thus housing submarket price formation is related to the whole history of housing demand, supply and price in the submarket. Third, equations (16) and (17) can be re-written as

$$d_{ij}(t) = d_{ij}(0) + \sum_{\tau=0}^{t-1}(a_{ij}(x(\tau),\tau) - b_{ij}(x(\tau),\tau)) \quad (28)$$

$$s_{ij}(t) = s_{ij}(0) + \sum_{\tau=0}^{t-1}(c_{ij}(x(\tau),\tau) - b_{ij}(x(\tau),\tau)) \quad (29)$$

Combining with equation (27), it is clear that all the system stock variables $d_{ij}(t)$, $s_{ij}(t)$ and $p_{ij}(t)$ depend on the whole history of all the submarkets. And it is easy to prove that the housing demand, supply and housing price in a neighbourhood housing market are simply the aggregation of those of the sectoral housing submarkets (referring to equation (25-1) to (25-3)).

The above describes the dynamic system of a nested housing submarket structure. However an implicit assumption in this system is *'having entered the housing market, a household is actively searching in, at most, one of the channels at each point in time. However a searching household may reconsider its channel choice at any time;...Hence, while in reality many households are simultaneously searching in several channels, they may shift arbitrarily fast between channels but they are available for trade in one channel only at every point in time.'* (Weibull (1983), Page 383) The question is if and when the system can achieve an equilibrium, which we now turn to.

4.4 Housing Submarket Short Run Equilibrium

4.4.1 Equilibrium Condition

The system equilibrium condition can be defined, during a specific time interval T, to be:

1. in each sectoral housing submarket:

$$a_{ij}(x(t), t)=b_{ij}(x(t),t)=c_{ij}(x(t),t)= \text{constant}, t\in T \tag{30}$$

$$p_{ij}(t)=\text{constant} \tag{31}$$

and,

2. in each neighbourhood housing submarket:

$$a_i(x(t), t)=b_i(x(t), t)=c_i(x(t), t)=\text{constant}, t\in T \tag{32}$$

$$p_i(t) = \text{constant} \tag{33}$$

In equilibrium, all the behavioural functions are unchanged. There is no housing price movement in each submarket. The number of dwellings traded in each submarket is equal to the net housing demand rate and to the net housing supply rate. For this reason the index 't' can be dropped and the behavioural functions can be represented as a_{ij}, a_i, b_{ij}, b_i, c_{ij}, c_i and the prices as p_{ij}, p_i. This implies that, even in equilibrium, there exists *unsatisfied* demand and supply.

Substituting these conditions into equations (16) to (18) and (22) to (24), the following equations can be obtained.

$$d_{ij}=s_{ij}=\text{constant} \tag{34}$$

$$d_i=s_i=\text{constant} \tag{35}$$

This means that in each housing submarket, the effective housing demand and supply are both equal to constant in equilibrium.

Combining the above conditions with equation (25), it is not difficult to prove that if all the sectoral housing submarkets are in equilibrium, the neighbourhood submarkets will also be in equilibrium. But if all the neighbourhood submarkets are in equilibrium, the sectoral housing submarkets will not necessarily be in equilibrium. In other words, conditions (32) and (33) are necessary, though not sufficient, conditions for conditions (30) and (31) to hold. For this reason, the nested housing market equilibrium conditions are reduced to equations (30) and (31) only.

4.4.2 The Existence and Uniqueness of the Equilibrium

Proposition 1:

Suppose that the housing market satisfies the condition

$$D \geq \sum_{i,j} \varepsilon_{ij} * (\delta_{ij} - d^{*}_{ij})$$

This means that, at equilibrium, the total extra housing demand to the whole housing market is no less than the total extra housing supply. This implies that, at equilibrium, the housing market is demand oriented.

There exists a unique equilibrium point in the short run, i=1..I and j=1..J:

$$d^{*}_{ij} = s^{*}_{ij} = \frac{\varepsilon_{ij} * \delta_{ij}}{\beta_{ij} + \varepsilon_{ij}} \tag{36}$$

$$q^{*}_{ij} = \frac{1}{\beta_{ij}} = TF_{ij} \tag{37}$$

$$p^{*}_{ij} = -\frac{\alpha_2}{\alpha_1} * q^{*}_{ij} - \frac{\alpha_3}{\alpha_1} * X_{ij} - \frac{\lambda}{\alpha_1 * (1-\sigma)} Y_i + \frac{1}{\alpha_1} * \ln(\Pr^{*}_{j/i}) + \frac{1}{\alpha_1 * (1-\sigma)} * \ln(\frac{\Pr^{*}_{i}}{\Pr_{0}}) \tag{38}$$

Where,

$$\Pr^{*}_{j/i} = \frac{\varepsilon_{ij}*(\delta_{ij} - s^{*}_{ij}) + (\gamma^{1}_{ij} + \gamma^{2}_{ij})*d^{*}_{ij}}{\sum_{j}(\varepsilon_{ij}*(\delta_{ij} - d^{*}_{ij}) + (\gamma^{1}_{ij} + \gamma^{2}_{ij})*d^{*}_{ij})} \tag{39}$$

$$\frac{\Pr^{*}_{i}}{\Pr^{*}_{\bullet}} = \frac{\sum_{j}\gamma^{2}_{ij}*d^{*}_{ij} + \sum_{j}\varepsilon_{ij}*(\delta_{ij} - s^{*}_{ij})}{D - \sum_{k,j}\varepsilon_{kj}*(\delta_{kj} - s^{*}_{kj})} \tag{40}$$

(The proof is given in Appendix 4-1 and '*' denotes short run equilibrium).

As in each neighbourhood submarket:

$$d^{*}_{i} = \sum_{j} d^{*}_{ij}$$
$$s^{*}_{i} = \sum_{j} s^{*}_{ij}$$
$$p^{*}_{i} = \sum_{j} p^{*}_{ij}$$

the neighbourhood equilibrium point can be obtained from equations (36) to (38) simultaneously. Therefore the sectoral housing submarkets and the neighbourhood housing submarkets achieve short run equilibrium at the same time. Any changes of the housing market parameters, e.g. a change of vacancy rate, may violate short run equilibrium.

4.4.3. Some Static Properties of Housing Submarket Short Run Equilibrium

A number of equilibrium static properties can be derived from the above proposition (if other things remain unchanged).

Property One

In each sectoral or neighbourhood housing submarket, the equilibrium housing demand (supply) is a strictly increasing function of the submarket dwelling stock. More dwelling stock in a submarket attracts more effective housing demand.

Property Two

In each sectoral or neighbourhood housing submarket, the equilibrium housing demand (supply) is a strictly increasing function of the submarket dwelling vacancy rates. Higher vacancy rates creates more dwelling supplies in the submarket. As a result, more demands are attracted to the submarket.

Property Three

A seller's waiting time in a housing submarket is an increasing function of housing submarket trade friction.

Property Four

In each sectoral or neighbourhood housing submarket, the equilibrium housing demand (supply) is a strictly decreasing function of β_{ij} (see equation (36)). This is because smaller β_{ij} is related to a larger submarket trade friction, which accumulates the effective housing submarket demand as well as supply. In other words, the number of dwellings traded during a specific time is reduced.

When β_{ij} tends towards zero, the submarket equilibrium housing demand and supply will tend towards their maximum point. All the buyers will be engaged in housing search and all the sellers will be waiting to sell their dwelling. No trade happens.

When β_{ij} tends towards 1, the dwelling transaction in this housing submarket will tend towards its maximum point and the effective housing demand and supply will tend towards their minimum point, which will be equal to the number of dwellings transacted in that submarket (see equation below).

$$d_{ij} = s_{ij} = b_{ij} = \frac{\varepsilon_{ij} * \delta_{ij}}{1 + \varepsilon_{ij}}$$

Property Five

In equations (3), (4) and (38), α_1 and α_2 are negative real numbers. α_3 and λ are the coefficients of X_{ij} and Y_i, which represent the qualities of the sectoral and neighbourhood housing submarkets, therefore, they are positive real numbers. Equation (38) can be re-written as:

$$\begin{aligned} \dot{p}_{ij} = & -\frac{\alpha_2}{\alpha_1} * \dot{TF}_{ij} - \frac{\alpha_3}{\alpha_1} * X_{ij} - \frac{\lambda}{\alpha_1 * (1-\sigma)} Y_i + \\ & \frac{1}{\alpha_1} * \ln(\dot{Pr}_{i/i}) + \frac{1}{\alpha_1 * (1-\sigma)} * \ln(\dot{Pr}_i) - \frac{1}{\alpha_1 * (1-\sigma)} * \ln(\dot{Pr}_0) \end{aligned} \quad (41)$$

It follows that, in each sectoral housing submarket:

1. the equilibrium submarket housing price is a strictly decreasing function of submarket trade friction. Equation (37) shows that higher housing submarket trade friction results in a longer waiting time for the sellers. This is because housing submarket trade friction is determined by how well the dwellings in that submarket suit to the buyers' housing preferences (Section 3.4). A poor match will arise where the sellers' waiting time in the

submarket is high. This will further reduce the buyer's expectation of the future housing price increases in that submarket. The result is that less demand will go to that submarket. The price will fall.

2. the equilibrium submarket housing price is positively related to the dwelling related components in that submarket. In other words, housing price is partly determined by the neighbourhood components as well as the dwelling components;

3. the equilibrium submarket housing price is positively related to the buyers' choice probabilities for the submarkets $Pr^*_{j/i}$ and Pr^*_i, and is negatively related with the buyers' choice probability of leaving the submarket Pr^*_0.

Substituting equation (36) into equations (39) and (40) and then replacing $Pr^*_{j/i}$ and Pr^*_i in equation (41) by equations (39) and (40), an implication can be drawn from the above three conclusions. This is that in a housing submarket, the equilibrium housing price is determined by the housing submarket factors only, given that in the short run household housing preferences are unchanged. The factors are: submarket trade friction (TF_{ij}), dwelling related components(X_{ij} and Y_i), housing stock (δ_{ij}), dwelling vacancy rate (ε_{ij}) re-choice rates (γ^k_{ij}) and the total extra housing demand inflow to the housing market (D). Any change of these factors will change the short run equilibrium position.

An other implication is that the equilibrium submarket housing price is a strictly increasing function of the extra housing demand inflow (D). This is derived from equations (38) and (40). It implies that in an urban or regional housing market, the increase of net migration into the area will increase each submarket housing price.

4.5. The Stability of Housing Submarket Short Run Equilibrium

4.5.1 A New View of Equilibrium Stability

Stability analysis is an important part of equilibrium theory as many economic theories depend on the comparative static of equilibrium and the equilibrium properties make sense only if the underlying system is stable. Conventional equilibrium theory considers three types of equilibrium stability. They are: *Global Stability, Neighbourhood Stability* and *Instability* (Weibull 1983). In this section, this approach is extended and four types of stability will be discussed in terms of the degree of stability. They are:

Global Stability

↓

Neighbourhood Stability

↓

Bounded Instability

↓

Instability

Global Stability is defined as that a market price will converge to equilibrium from any disequilibrium position. Neighbourhood Stability is defined as that a market price will only converge to equilibrium from a disequilibrium position which is within the neighbourhood of its equilibrium price. Bounded Instability is a mixture of stability and instability. It is defined as that the dynamics of a market price, after it moves from its equilibrium to a disequilibrium position which is within the neighbourhood of its equilibrium position, will be bounded in its equilibrium neighbourhood. Instability is defined as that once the market leaves its equilibrium position, it will not be able to return to equilibrium.

Is the dynamic stock-flow equilibrium discussed in Section 4.4 a stable one? What determines housing submarket equilibrium stability? How do the submarket housing prices move and what is the key force directing housing submarket operation? To answer these questions it is necessary to undertake a computer simulation of the system defined in the model above. The stability properties are ascertained from the simulation results.

4.5.2 Computer Simulation Procedure

The housing submarket system used in the simulation is an artificial one. It is randomly identified by Program One (Appendix 4-4). The output of program one is a group of housing submarket parameter values (An example is given in Table 1 in Appendix 4-3). These values, i.e. $D, \varepsilon_{ij}, \delta_{ij}, \beta_{ij}, \gamma^{k}_{ij}, (1-\sigma), \alpha_1, \alpha_2, \alpha_3, X_{ij}, \lambda, Y_i$ (The definitions are given in Appendix 4-2) are inter-related and satisfy the equilibrium conditions in Section 4.4.1&4.4.2. The housing submarket system identified has a nested housing submarket structure defined in Chapter III.

Program two is a simulation program of the nested housing submarket (identified by program one) operation (Appendix 4-5).

The simulation starts from an equilibrium point, then either submarket housing prices or other market parameters are changed, which will push the housing market to a disequilibrium position. The dynamic process of the housing submarket operational process is recorded to see how and in which condition the housing submarkets go back to equilibrium.

The two programs are implemented using Turbo-C on IBM-PC compatible machines. The simulation results are explained in terms of discrete time, namely simulation time(s).

4.5.3. Short Run Dynamics of Housing Submarket System

This section focuses on the short run dynamic properties of a nested housing submarket system. It is assumed that, during the simulation the market related parameter values, e.g. $D, \varepsilon_{ij}, \delta_{ij}, \beta_{ij}, \gamma_{ij}^{k}, (1-\sigma), \alpha_1, \alpha_2, \alpha_3, X_{ij}, \lambda, Y_i$ are unchanged. Only submarket house price change is emphasised.

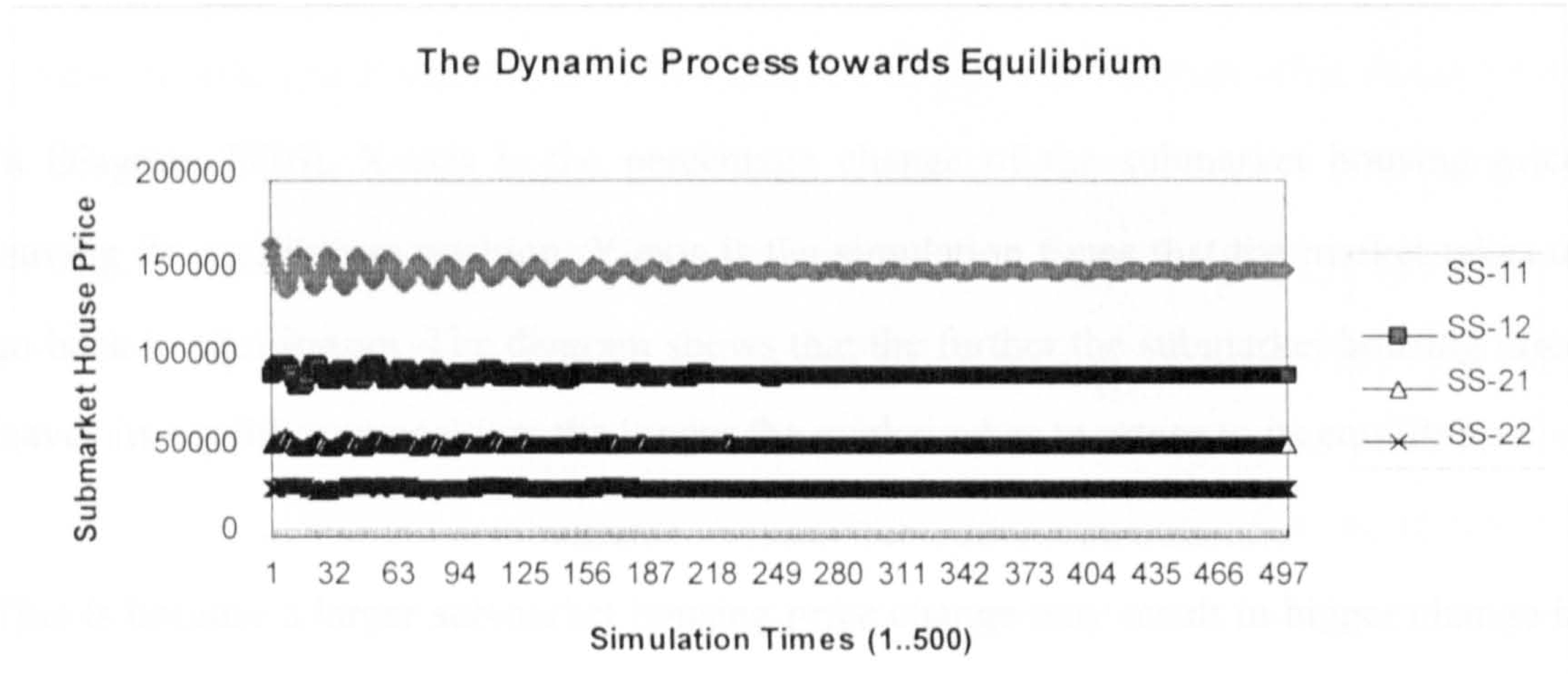
A large number of simulations have been performed to simulate a two level nested housing submarket operation (see Diagrams IV(1)&(2) in Chapter IV and Appendix 4-3). The results show that, in the short run, a nested housing submarket equilibrium is either Neighbourhood Stable, or Bounded Instable or Instable, which is determined by the housing submarket structure. In particular, it is related to the differences between the submarket equilibrium house prices. The larger the difference is, the more stable the submarket equilibrium is. This is shown by the following three simulation cases.

These three simulation cases are produced based on three different housing submarket system. Their difference is, in the first case, submarket equilibrium house prices are widely distributed and this type of submarket structure is named as *Loose* Housing Submarket Structure; in the third case, submarket equilibrium house prices are very close and this type of housing submarket structure is named as *Tight* housing submarket structure; and in the second case, the distribution of the submarket equilibrium house price is between the first and the third cases and this type of housing submarket structure is named as *Normal* housing submarket structure. Some main simulation results related to the above three cases are given in Appendices 4-6 to 4-8 separately. The results are presented by diagrams. In order to simplify the discussion below, the results at sectoral housing submarket level are presented for discussion. This is because the results at neighbourhood level are simply the linear aggregation of the results at sectoral level. The results at neighbourhood level are given in Appendix 4-6 to 4-8.

1. Case One: short run equilibrium with neighbourhood stability

Case One presents an example of housing submarket equilibrium with neighbourhood stability. The values of the parameters used in this simulation are listed in Appendix 4-3 and Appendix 4-6.This market has a *loose* housing submarket structure.

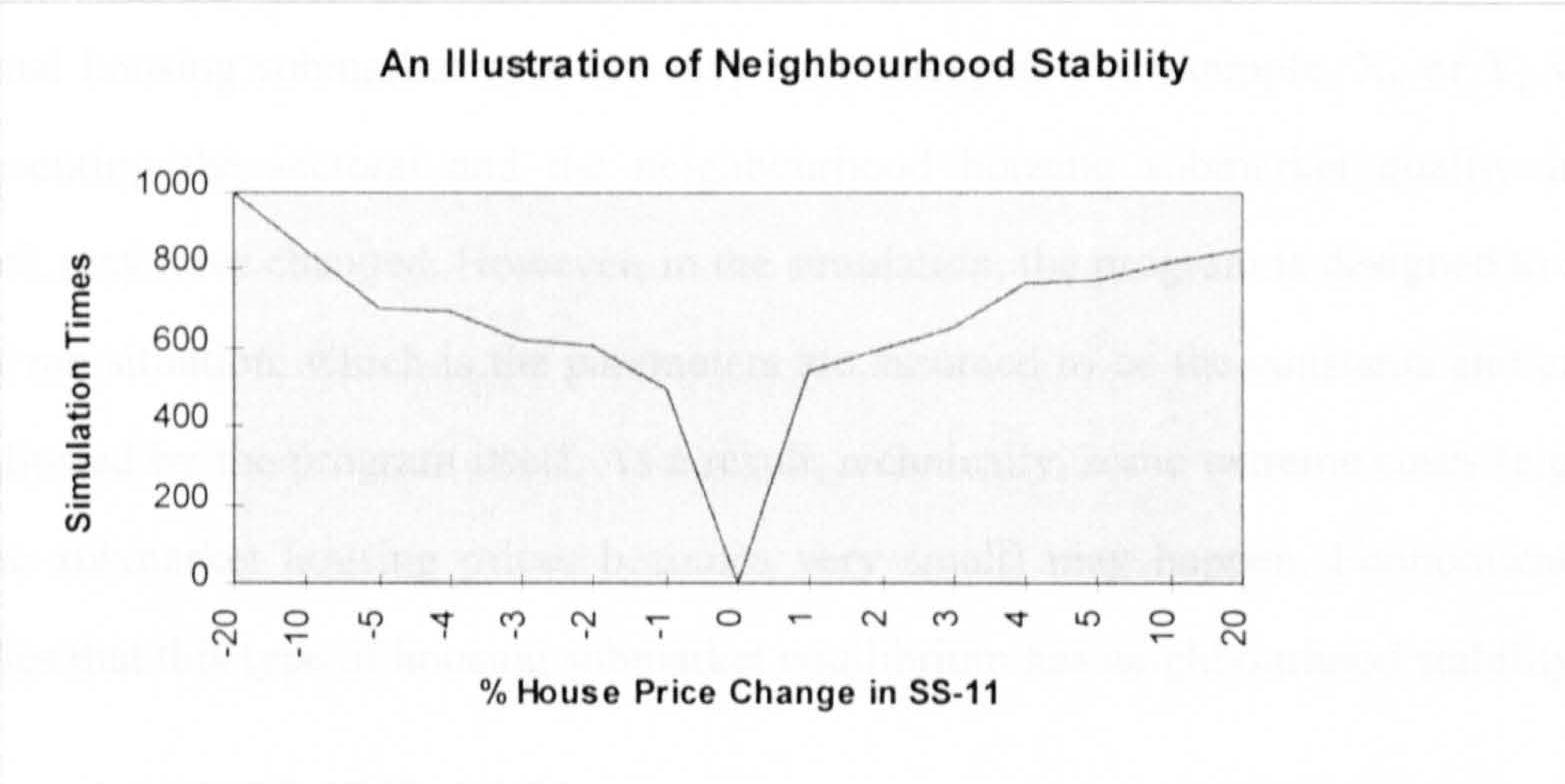
Diagram IV(5)



The simulation starts from an equilibrium position. The housing price in sectoral housing submarket 'SS-11' is increased 1%, then the whole housing submarket system is brought into a disequilibrium position. Keeping other parameters unchanged, the system returns to equilibrium after about 500 simulations.

However, only when the submarket housing price change is within the neighbourhood of its equilibrium price, the whole system can return to equilibrium. This is illustrated by Diagram IV(6).

Diagram IV(6)



In Diagram IV(6), X-axis is the percentage change of the submarket housing price leaving its equilibrium position. Y-axis is the simulation times that the market takes to go back to equilibrium. The diagram shows that the further the submarket housing price leaves its equilibrium position, the longer the market takes to return to its equilibrium.

This is because a larger submarket housing <u>*price*</u> change may result in bigger change in the buyers' choice <u>*probability*</u> for the submarket (Equations (3)-(6) in Chapter IV), which will cause a bigger change of the housing <u>*demand distribution*</u> across the submarkets. This will further cause the larger changes of other submarket housing <u>*prices*</u>. As a result, the market will take a longer time to go back to equilibrium.

This implies that there exists a neighbourhood boundary around the equilibrium position. The market can return to equilibrium if any housing price change is within the boundary, otherwise, the market will turn to disequilibrium.

In this case, when the submarket housing price decreases -20% from its equilibrium price, the simulation results are out of control, e.g. in some housing submarkets, the housing price becomes either very cheap or very expensive with a very unstable market situation.

This is because a very big change of the submarket housing price implies that the original housing submarket structure may have changed. For example, X_{ij} or $Y_{i.}$ which representing the sectoral and the neighbourhood housing submarket quality in the model, may have changed. However, in the simulation, the program is designed to suit a short run situation, which is the parameters are assumed to be the constants and cannot be adjusted by the program itself. As a result, technically, some extreme cases (e.g. one of the submarket housing prices becomes very small) may happen. Economically, it implies that this type of housing submarket equilibrium has neighbourhood stability.

Another interesting phenomenon is that Diagram IV(6) has an unsymmetric shape. when the submarket housing price increases (the right part of the diagram), the market takes a shorter time to return to equilibrium than the case of the submarket housing price decreases (the left part of the diagram). Looking back to the housing submarket structure in this case (Appendix 4-6), it is shown that if the housing price in that submarket increases, the whole housing submarket system becomes less segmented. If the housing price in that submarket decreases, the whole housing submarket system will become more segmented. Therefore, the implication is that the market equilibrium stability is related to the segmentation of the system. This conclusion will be further proved by Cases 2&3.

This dynamic process implies that the buyer's housing search behaviour and the housing choice probability are the key forces in directing housing submarket operation. The sequence is: the submarket housing price change results in the household housing preference change (both the search behaviour and the choice probability), which redistributes the housing demand between the submarkets. Other submarket housing prices will be changed, which may further influence the household housing preference. This cycle is illustrated by Diagrams 1 to 4 (the dynamic process of the household housing submarket choice probabilities); Diagrams 5 to 8 (the dynamic process of the submarket housing prices); and Diagrams 9 to 12 (the dynamic process of the submarket housing demands) in Appendix 4-6.

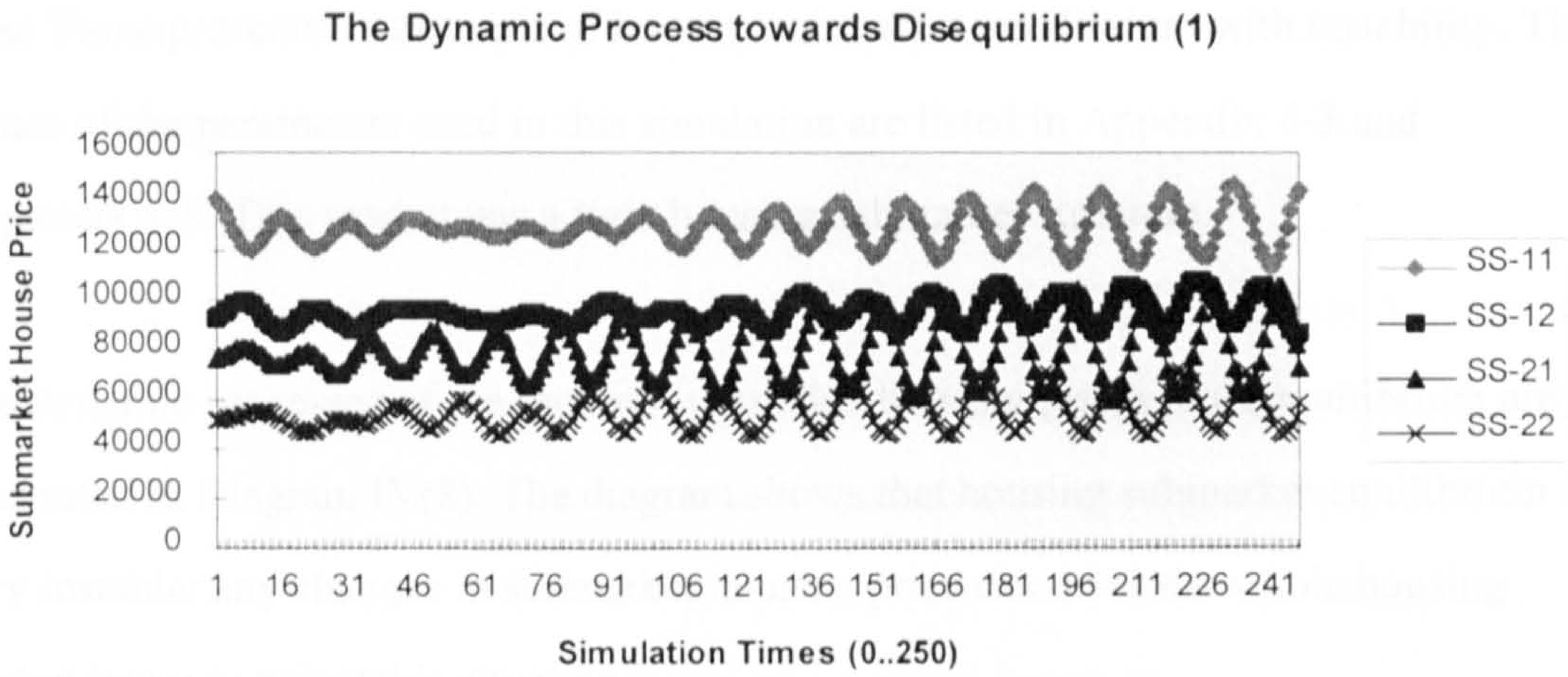
As housing choice probability takes a key role in directing housing submarket operation, it implies that, if the buyers become more sensitive to the changes of the submarket housing price or to the changes in the expectation for the future house price (which is represented by the sellers' waiting time in the model), the housing submarket system will be less stable. In other words, the neighbourhood range which keeps the system equilibrium stable will be small

2. Case Two: short run equilibrium with bounded instability

Case Two presents an example of housing submarket equilibrium with bounded instability. The values of the parameters used in this simulation are listed in Appendix 4-3 and Appendix 4-7. This market has a *normal* housing submarket structure.

The dynamic processes of the sectoral submarket housing prices to disequilibrium are illustrated in Diagram IV(7). The diagram shows that, in this housing submarket structure, equilibrium has bounded instability. The meaning of bounded instability is illustrated by the diagram below. The diagram shows that the dynamics of the submarket housing prices are within the neighbourhood of their equilibrium position.

Diagram IV(7)



The simulation shows that if the initial housing price change is out of the neighbourhood of its equilibrium price, the results are out of control, i.e. some submarket housing prices will become either very cheap or very expensive. The market situation becomes very instable. This implies that, for this type of housing submarket structure, there exists a neighbourhood boundary. If the initial housing price change is within the boundary, the market will be in a *bounded instable* situation (See the diagram), otherwise, the market will turn to *totally instable* situation.

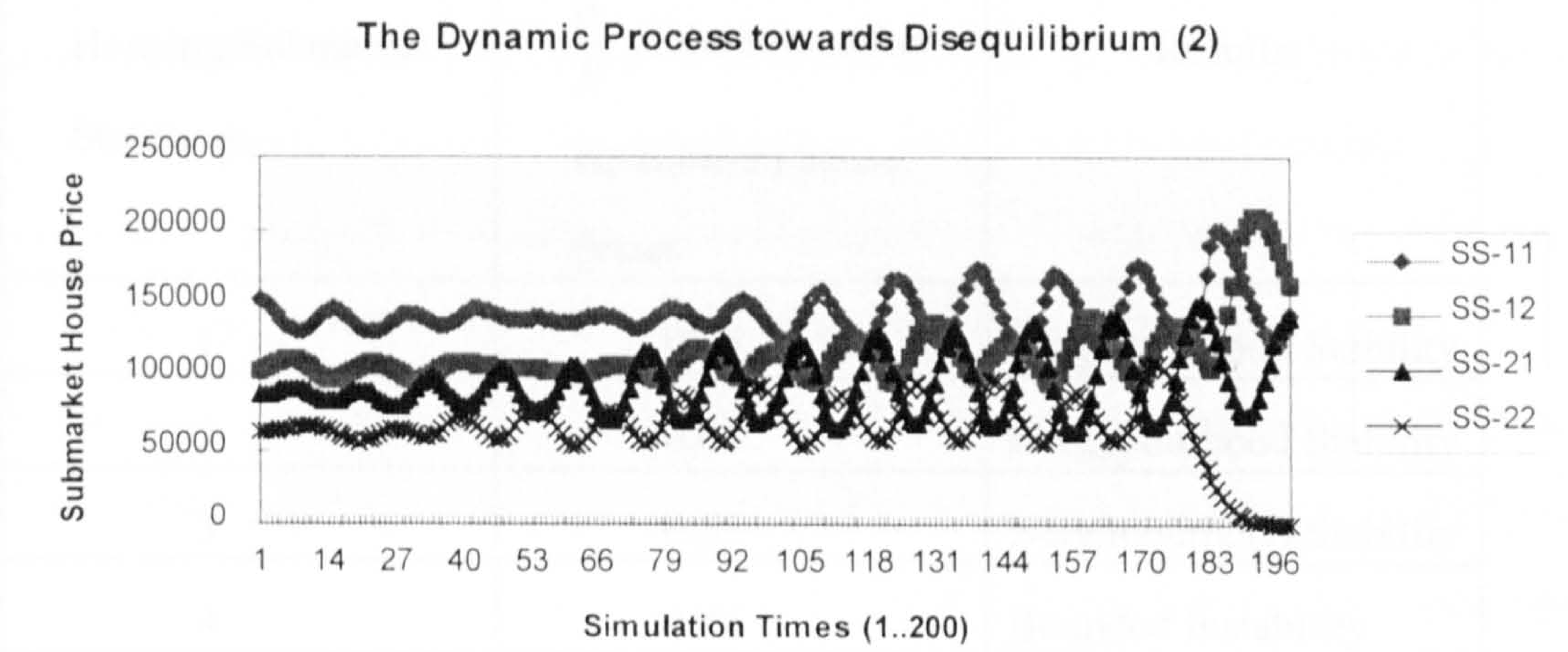
The results in this case are consistent with the results in the first case. Any submarket housing price change will change the buyers' choice probabilities for the different housing submarkets. As a result, the total housing demand will be re-distributed among the housing submarkets. This process is illustrated by Diagrams 1 to 4 (the dynamic processes of the household housing submarket choice probabilities); Diagrams 5 to 8 (the dynamic processes of the submarket housing prices); and Diagrams 9 to 12 (the dynamic processes of the submarket housing demands) in Appendix 4-7.

3. Case Three: short run equilibrium with instability

Case Three presents an example of housing submarket equilibrium with instability. The values of the parameters used in this simulation are listed in Appendix 4-3 and Appendix 4-8. This market has a *tight* housing submarket structure.

The dynamic processes of the sectoral submarket housing prices to disequilibrium are illustrated in Diagram IV(8). The diagram shows that housing submarket equilibrium is very instable: any changes in submarket housing price can drive the whole housing market into a very instable situation.

Diagram IV(8)



The conclusions from this case are consistent with the conclusions of the last two. Any submarket housing price change will change the buyers' choice probabilities for the different housing submarkets. As a result, the total housing demand will be re-distributed among the housing submarkets. This process is illustrated by Diagrams 1 to 4 (the dynamic processes of the household housing submarket choice probabilities); Diagrams 5 to 8 (the dynamic processes of the submarket housing prices); and Diagrams 9 to 12 (the dynamic processes of the submarket housing demands) in Appendix 4-8.

Now the question is why the degree of equilibrium stability becomes enfeeble: from neighbourhood stability (case one) to bounded instability (case two), till instablility (case three).

Comparing the housing submarket structures, it is found that the similarity between the submarket equilibrium housing prices is the reason of contributing to the housing submarket stability/instability. This conclusion can be further proved by Table IV(1). In the table, from Structures 5 to 6, the equilibrium stability of the housing submarket systems simulated changes from Bounded Instability to Instability.

Table IV(1)

Housing Submarket Equilibrium Stability and Housing Submarket Structure

Housing Submarket Structure	$\frac{\sigma}{\overline{X}}$ of the submarket equilibrium house prices	Results
1	0.66	Neighbourhood Stability
2	0.61	Neighbourhood Stability
3	0.55	Neighbourhood Stability
4	0.44	Bounded Instability
5	0.36	Bounded Instability
6	0.35	Instablility
7	0.32	Instability

If other things are unchanged, the difference of the buyers' housing preferences for the different housing submarkets in a less segmented (tight) housing submarket structure is smaller. This implies that there is a higher housing choice substitution between the housing submarkets. When the housing price in one housing submarket changes, there will be a larger scale of housing demand re-distribution between the submarkets. Therefore housing submarket equilibrium is less stable in this structure.

The Diagrams IV(5), (7) and (8) have also shown that there is a spatially lagged effect between the submarket housing prices.

For example, in Diagram IV(5), the equilibrium housing price in SS-11 is increased and the equilibrium condition in this submarket is broken first. The effect is transmitted to other housing submarkets through the changes of the buyers' choice probabilities for the different housing submarkets. As a result, the housing prices in other housing submarkets will change. But the diagram also shows that the effect on the other submarket housing prices are decreasing with spatial distance. This is because a buyer's location choice is also influenced by the distance to the work place, to the city centre or to the relatives'/friends' dwelling location. His preference for housing submarkets has a spatial constraint. As a result, when the housing price in one sectoral housing submarket is changed, it will have a bigger influence on the buyer's preference for this submarket, and the other sectoral housing submarkets located in the same neighbourhood. Such influence will decrease on the sectoral housing submarkets located in the adjacent or the remote neighbourhoods. The conclusion from the above discussion is that, in a local housing submarket system, there exist both spatial and auto correlation between the submarket housing prices, which is caused and directed by the buyers' housing search behaviour.

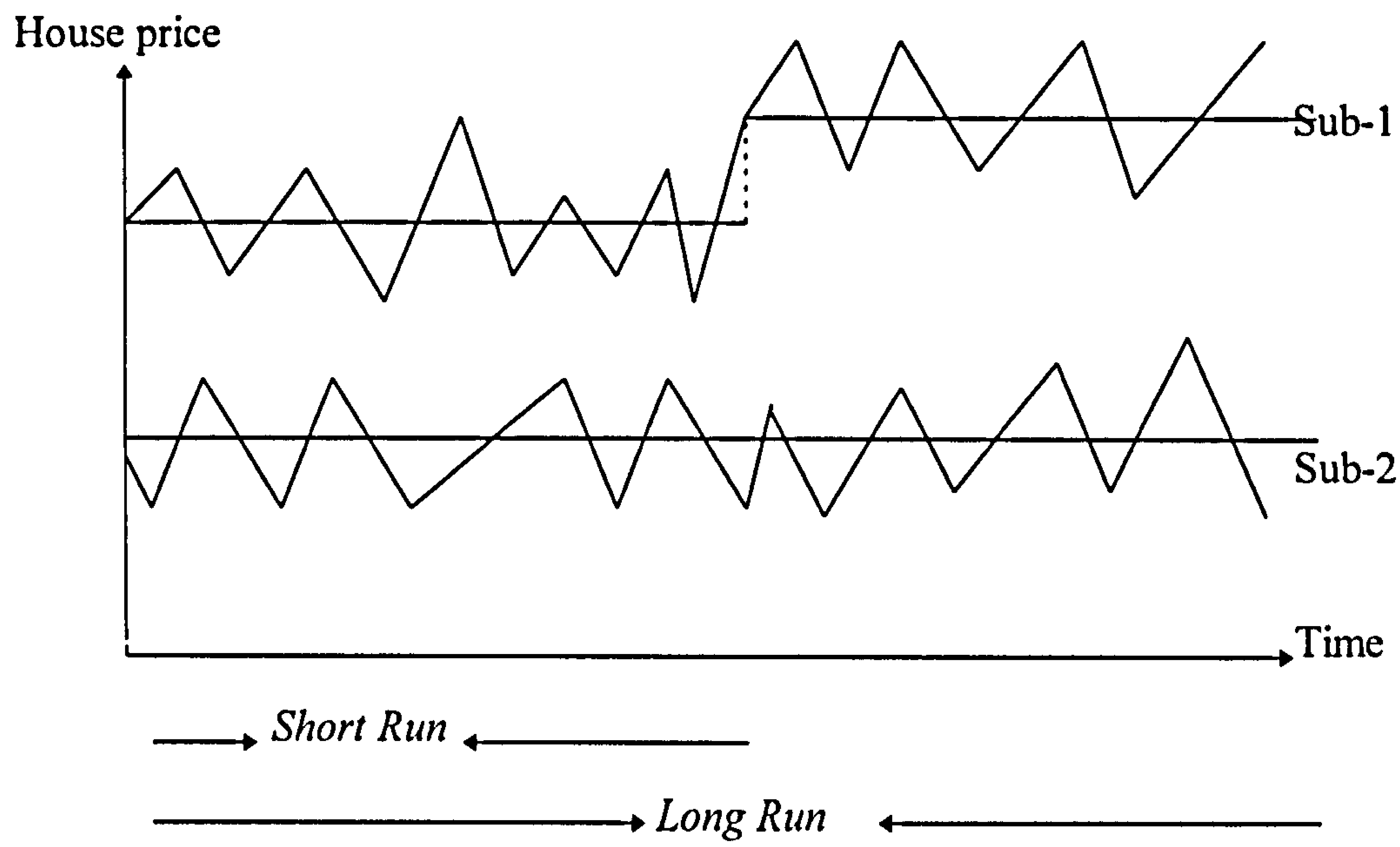
4.5.4 Implications in the Long Run

In the long run, any of the factors listed in the model can be changed, which will shift the submarket equilibrium position. The long term consequence of such change is housing submarket structure may change. The submarket housing prices will be either drifting apart or moving closer.

The change of housing submarket trade friction. If other factors are unchanged, but the housing submarket trade friction is reduced (e.g. as a result of the household housing preference change or the area re-generation), the submarket equilibrium housing price will be increased, the whole local housing market will be located in a new equilibrium position (See Diagram IV(9)). Suppose that there are only two housing submarkets. Trade friction in one submarket (sub-1) is reduced, the new equilibrium position for the submarket will be shifted up. The whole local housing submarket structure will be changed. In this case, the two housing submarkets are drifting apart.

Diagram IV(9)

The Long Run Trend of a Housing Submarket Structure (1)

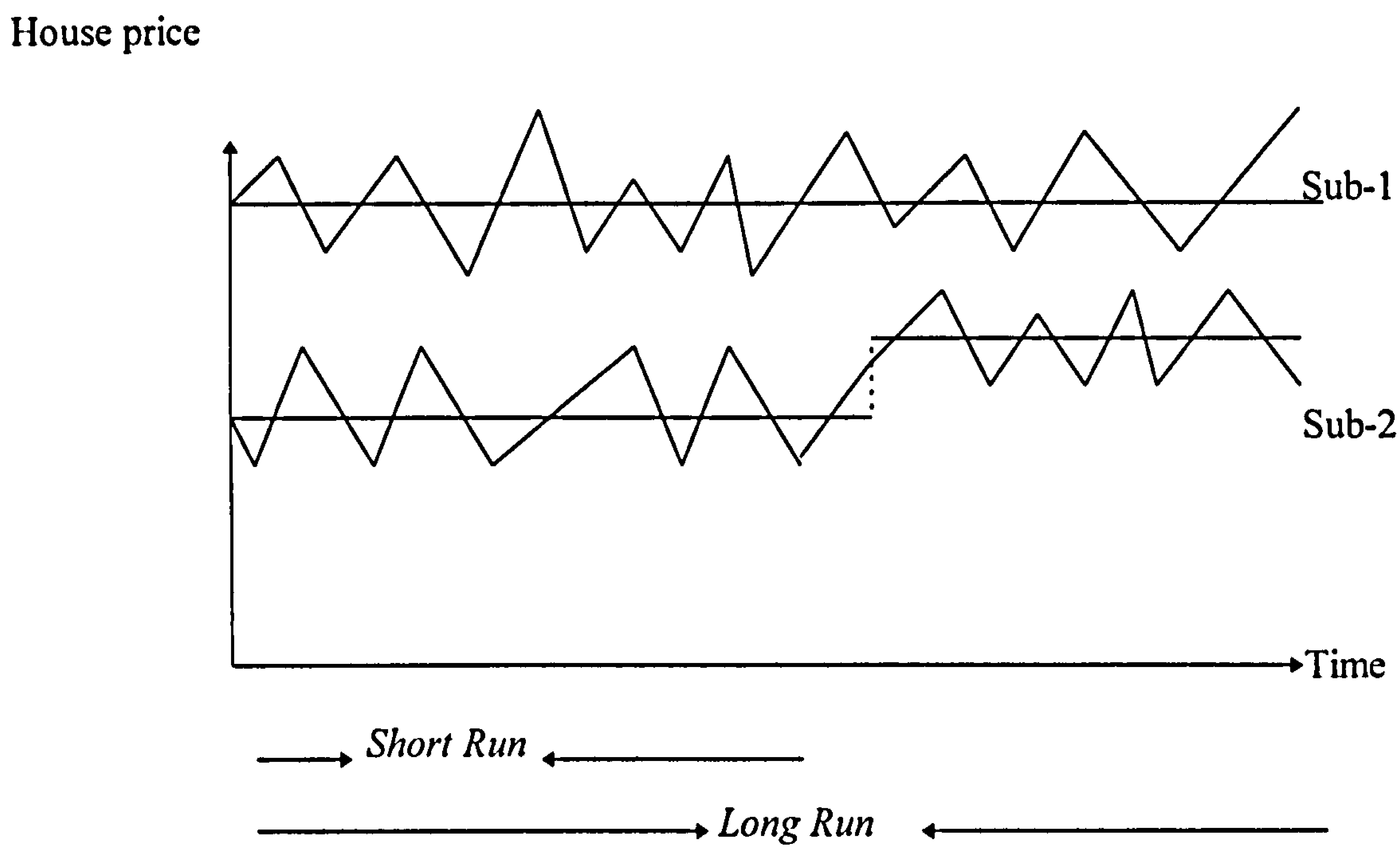


The change of physical dwelling quality. This change can be a result of dwelling maintenance, or area regeneration, which will increase the submarket dwelling price.

The whole local housing market will be located in a new position. The housing submarket structure will be changed too (See Diagram IV(10)). Suppose that the dwelling quality in one submarket (sub-2) is improved, the new equilibrium position for the submarket will be shifted up. In this case, the two housing submarkets are moving closer.

Diagram IV(10)

The Long Run Trend of a Housing Submarket Structure (2)



The change of the household housing preference. When the buyers become more keen on a particular type of dwelling, for example, in a local housing market, the small flats located in the central area is becoming more popular than before, the submarket housing price will be increased. Therefore, the submarket structure will be changed too.

The change of the local population or the housing stock. The increase or decrease of the local population may increase or decrease all submarket housing prices. The whole housing market will be located in a new position. The structure change of the local housing submarket will depend on how the relative housing prices change. The change of housing stock, for example, building up new towns, will certainly change the local housing submarket structure. The changing pattern will be uncertain and largely depend on the relative submarket housing price change.

In the long run, the housing submarket structure change can be serious, i.e. some housing submarkets may have deteriorated whilst others remain unchanged or become prospered.

Diagram IV(11)

The Long Run Trend of a Housing Submarket Structure (3)

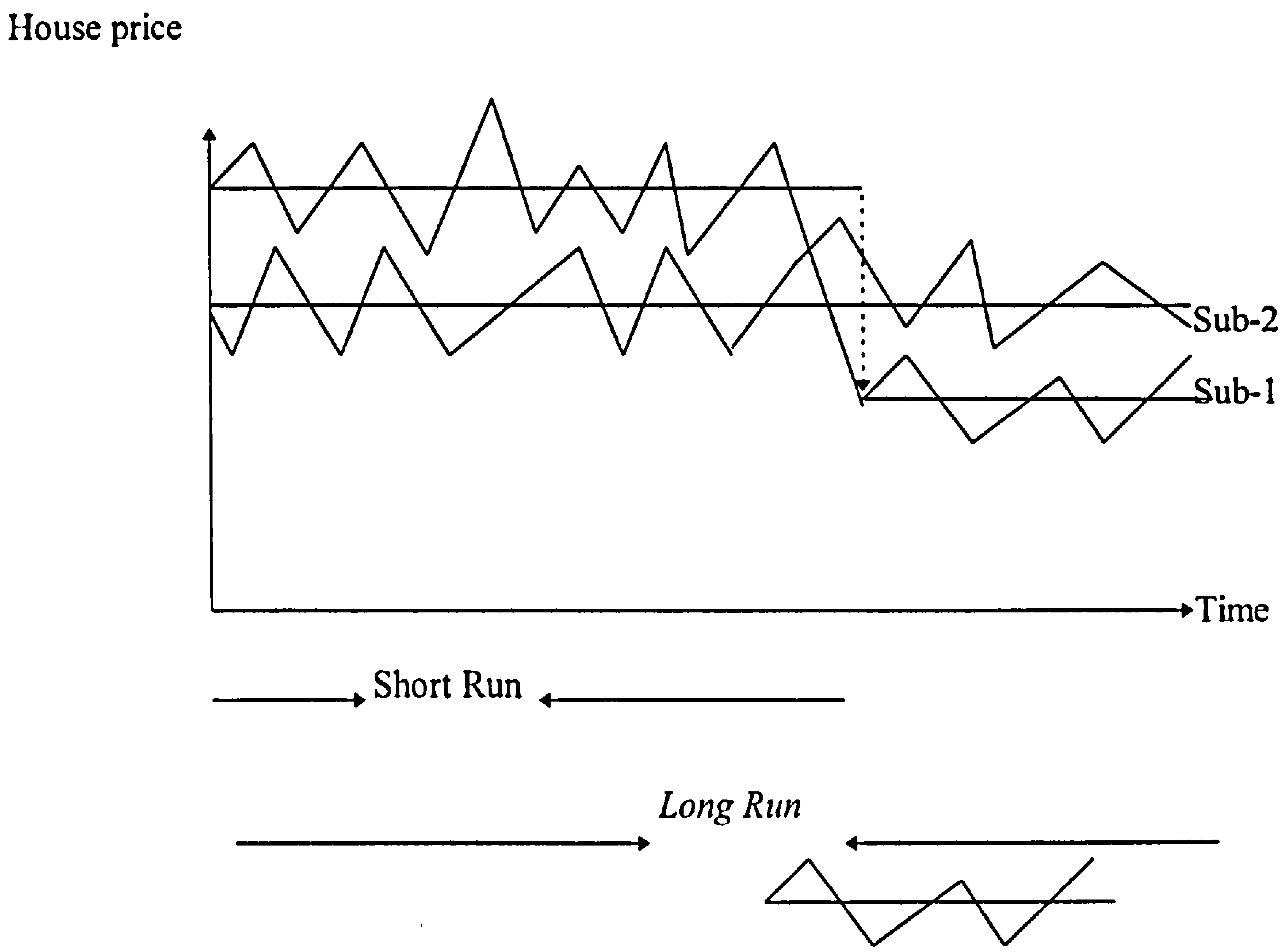


Diagram IV(11) shows that one submarket housing price could possibly drop below the other one.

The model in this chapter provides a new framework for the housing submarket analysis. The main conclusion is: in the short run, the housing market is in a neighbourhood disequilibrium and in the long run a local housing submarket structure can change as a result of the submarket related components change (Section 4.4). Two more questions arise from it. One is how to empirically identifying a local housing submarket structure based on the above framework. The other is how to empirically estimate the buyers' housing choice probability for the different housing submarkets.

A large volume of academic literature in the 1980s has been devoted to empirically identify a housing submarket (i.e. Goodman 1981, Maclennan, Munro & Wood 1988). The basic procedure is: 1. describing the internal (non-spatial), neighbourhood and accessibility (spatial) components of each dwelling unit (See Chapter III). These components have different functions in identifying the housing submarket structure; 2. clustering the individual dwellings, by factor or principle component analysis, into product groups (PG), which are constructed both spatially and sectorally (See Chapter III); 3. undertaking analysis of price variation and identifying local housing submarket structure based on the hedonic housing price analysis method (Pollakowski 1982). An example of this analysis based on a neighbourhood level housing submarket is given in Maclennan, Munro & Wood (1988). First, for each neighbourhood product group, a hedonic regression model is specified and estimated; second, within a metropolitan area the regression results for each PG are systematically compared for similarities and differences; third, there is an attempt to establish whether such price differences persist over a time period. Although sofar no empirical analysis is given based on a nested housing submarket structure defined in chapter III, the empirical work is just a repetition of the above procedure. Therefore, the analysis in the following chapters will not focus on this aspect, but will focus on modelling household housing choice behaviour in the circumstance of a nested housing submarket structure. As discussed in Chapter II, the previous housing choice behaviour modelling work didn't pay enough attention to the role of a housing submarket structure in household housing choice decision making process, especially at a regional level. This will be discussed in Chapter V to and VII.

Chapter V Modelling Household Housing Choice Behaviour per Submarket at Regional Level: a theoretical discussion

5.1 Introduction

Chapter IV explored the operational process of a local housing submarket system which has been identified as a nested housing submarket structure in Chapter III. The computer simulation results have shown that the buyers' housing choice probabilities for the different housing submarkets are the key force in directing the housing submarket operation. The changes of the buyers' housing preferences, i.e. the preference for the submarket housing price, will change the distribution of housing demand between the housing submarkets, as a result, the dynamic process of the whole housing submarket system operation will be changed. However, the review in Chapter II concluded that, empirically modelling housing choice behaviour at regional level has received little attention

The question is how a nested housing submarket structure influences a buyer's housing choice behaviour, especially at regional level where the spatial dimension of a housing market may play an important role in influencing the housing choice behaviour? A housing submarket can be identified by a number of factors: i.e. submarket housing price, trade friction, location, dwelling type or size. Which of them are the key factors influencing the buyers' housing choice for a submarket? Chapter II has given an extensive review of housing choice models, but none of them can be used to answer this question.

Briefly, three principal disadvantages of the previous housing choice models (e.g. Quigley 1976, 1985, Louviere 1979) can be drawn from the discussion in Chapter II.

1. The previous research isolates a household's housing choice behaviour from the local housing submarket structure. The influences of the different submarket housing prices as well as the buyers' expectation for the future submarket housing price change on housing choice behaviour are ignored. Therefore, the selection of the independent variables in these models lacks theoretical underpinning. In other words, they mainly emphasis the goodness of fit, but less concern the economic interpretation of the independent variables.

2. Distance to the work place has been considered as an important factor influencing housing choice behaviour. For example, some urban housing choice models measure this effect using the distance to the CBD (Alonso 1978). Within a large urban area where there are several employment centre or subcentres, this effect is measured by the distance to the work place. Quigley (1976) have examined this effect in the USA housing market. However, there has been lack of empirical evidence in the UK regional housing market. The distinct feature in the UK regional housing market is that regional residential dwelling distribution is shaped by its nuclei employment structure (see Chapter III). Therefore understanding and measuring the influence of this nuclei structure on housing choice behaviour is important.

3. The availability of dwelling supply in a submarket and its influence on the disaggregate housing demand forecast are ignored. Using revealed choice information may therefore bring estimation biases to forecasting as a buyer's real housing choice may not represent his/her real housing preference because of the dwelling supply constraints. Louviere (1979) used a stated preference method to collect housing preference information. Although his method, to some extent, remedied the above deficiencies, a new problem was inherent, which was that some people might over- or under- estimate their housing preferences. The above implies that there is a need to combine a household's *revealed* housing preference and *stated* housing preference to obtain the 'true' housing preference information.

The model introduced in this Chapter is designed to remedy the above three disadvantages. Section 5.2 introduces the economic approach to a dwelling choice. A hierarchical conceptual framework, which can be used to forecast housing demand by a submarket as well as by an individual dwelling is set up in Section 5.3. Based on this framework, the housing demand forecasting procedure, variable selection and a housing information collection strategy are derived.

5.2 The Economic Approach for a Dwelling Choice

5.2.1 The Definition of a Hierarchical Dwelling Choice Set

A dwelling is a complex economic commodity. '*The principal features of the housing commodity which distinguish it from most goods traded in the economy are its relatively high cost of supply, its durability, its heterogeneity and its locational fixity*' (Quigley 1983, page 25).

The features of durability, heterogeneity and locational fixity indicate that the housing market consists of a group of closely related, but spatially or sectorally segmented housing submarkets, which are differentiated by size, type, and neighbourhood conditions as well as submarket house prices. These submarkets are connected in a complex way, for example, the nested housing submarket structure outlined in Chapter III (see Diagram III(1) of Chapter III).

In this nested housing submarket structure, the dwellings in each sectoral housing submarket are homogeneous. This implies that the dwellings in a sectoral housing submarket have the same bundle of key dwelling components but different bundles of non-key dwelling components (Chapter III).

Before a buyer chooses a specific dwelling, he/she has already chosen a sectoral housing submarket as well as the related neighbourhood housing submarket. The alternatives in a choice set faced by a buyer thus have a hierarchical structure.

The first level alternatives are the neighbourhood housing submarkets; the second level alternatives are the sectoral housing submarkets and the third level alternatives are the individual dwellings in each sectoral submarket.

The alternatives are assumed as the discrete alternatives although some components, such as distance to the work place or house price, are continuous variables. Therefore, each buyer has only one final choice. This means that the total utility that a buyer can obtain from one dwelling is different from that of any others.

5.2.2 Rational Behaviour

The essence of economic choice theory is that a buyer's choice behaviour in a market is generated by the maximisation of his/her choice utility. The choice utility is derived from consuming the services which are provided by the components of the commodity. For example, if the commodity is a dwelling, the rooms will provide the service of sheltering and the kitchen will provide the service of cooking.

A choice is a rational choice if it satisfies three axioms: the axiom of completeness, the axiom of transitivity and the axiom of greed, or satiation (Maclennan & Williams 1980).

(1) The buyer makes a rational preference ranking of all the potential dwellings which he/she knows in the market. (The axiom of completeness)

(2) If the buyer prefers Dwelling A to Dwelling B, and prefers Dwelling B to Dwelling C, then he/she will prefer Dwelling A to Dwelling C. (The axiom of transitivity)

(3) A buyer will always prefer Dwelling A to Dwelling B if Dwelling A can provide more of at least one service to the buyer than Dwelling B can. (The axiom of greed and satiation)

Although as pointed out in Chapter III, a buyer enters the market with imperfect information, in the real world, a buyer rarely makes his/her final choice of a dwelling with imperfect market information. This is because buying a dwelling is one of the largest expenditures for most of the households, he/she would rather undertake an extensive housing search to obtain full market information than make a choice in a rush. A full discussion about the search process was given in Chapter III & IV. So, it is reasonably to assume that each buyer will buy a dwelling after obtaining full market information. Under this assumption, the axiom of completeness will be satisfied.

The axiom of transitivity denotes that a buyer is able to efficiently select the dwelling. He/she doesn't have to compare all the dwellings, but can eliminate the dwellings he/she has less preference for.

The axiom of greed and satiation means that under the budget constraint, a buyer will always prefer the dwelling which can provide him/her more services.

Based on the above approach, a buyer's utility derived from buying a dwelling can be described as:

$$U_{ij} = U(G_{ij}, S_1, S_2, \ldots S_k,) \quad (1)$$

where U_{ij} is the total utility buyer i obtains from the consumption of the j^{th} dwelling; S_k, k=1..K, is the total amount of the k^{th} type of service which the buyer obtains from the consumption of the j^{th} dwelling; G_{ij} is the services which the buyer obtains from the consumption of all other goods. Because of the budget constraint, the more a buyer spends on a dwelling, the less he/she can spend on other goods. The choice between G_{ij} and S_k reflects the constraint of a buyer's financial budget.

Although each buyer faces a hierarchical choice set, his/her choice for a dwelling depends on the total utility which he /she can obtain from consuming all the components associated with a dwelling and the related neighbourhood.

The amount of each type of housing service is produced from consuming at least one component. Each component can produce more than one service, e.g. a room can be used as a sleeping place or studying place. Different components may provide the same service, e.g. a garage and a front door parking area both produce the service of: 'parking'.

Different buyers have different cognitive abilities or perceptions (tastes) for the dwelling components, therefore, the same bundle of components may produce a different bundle of services for different buyers. But for one buyer, different bundles of components will produce different bundles of services, therefore, produce different utilities.

$U_{ij} \succ U_{ij'}$ for all j≠j', means that the total utility a buyer obtains from dwelling j is larger than from that for the dwelling j', if dwellings j and j' have different dwelling components.

However, the analysts are seldom able to 'peep-into-the-head' of a buyer and accurately calculate the amount of each service S_1, S_2...S_k. In order to make utility function (1) measurable, a specification is given below. In this specification, the dwelling components are used to measure the services.

$$U_{ij} = V_1(G_{ij}, C_1, C_2, ..C_m) + V_2(G_{ij}, C_1, C_2, ..C_m) + \mu_{ij} \qquad (2)$$

Where: μ_{ij} is the error term capturing the information on all the unmeasurable factors or inaccurately measured factors in the utility function; C_n, n=1..m, denotes the component, e.g. C_1 denotes a component of the dwelling size, C_2 denotes a component of dwelling type, or C_3 denotes a component of the neighbourhood; V_1 represents a buyer's preference for the components; V_2 represents a buyer's perception for the components.

Although many researchers have tried to identify a buyer's housing perception (MacFadden 1986), so far we have not found an efficient way to deal with this problem. In this study, V_2 will be treated as an error term in the empirical model calibration. Utility function (1) can be rewritten as:

$$U_{ij} = V_1(G_{ij}, C_1, C_2, ..C_m) + \varepsilon_{ij} \qquad (3)$$

where, $\varepsilon_{ij} = V_2(G_{ij}, C_1, C_2, ..C_m) + \mu_{ij}$.

A buyer's housing choice behaviour can be described by the following probability function:

$$\Pr_{ij} = P(U_{ij} \succ U_{ij'}. \forall j' \neq j)$$
$$\Pr_{ij} = P(V_1(G_{ij}, C_1, C_2, ..C_m) + \varepsilon_{ij} > V_1(G_{ij'}, C_1, C_2, ..C_m) + \varepsilon_{ij'}), \forall j \neq j') \qquad (4)$$

where, in this chapter, $\Pr_{ij}$ is the probability of the i^{th} buyer choosing the j^{th} dwelling.

Equation (4) means that the probability of a buyer choosing dwelling j' is the probability of which, the utility obtained from choosing dwelling j is bigger than the utility obtained from choosing any other dwelling j', j'≠j.

The economic approach of a dwelling choice implies that to explore household housing choice behaviour needs to empirically estimate the probability function (Eq (4). Two things have to be done in order to estimate the function: one is to select a statistical choice model. This is going to be discussed in Chapter VI; the other is to identify the components (also called as explanatory variables in the empirical analysis) outlined in equation 4. The identification will take two steps: first, to set up a theoretical housing choice model (Section 5.3), which provides a theoretical foundation of explanatory variable selection; second, to empirically identify and estimate these variables (Chapter VII).

5.3 A Conceptual Framework of Housing Choice Forecasting Model at Regional Level

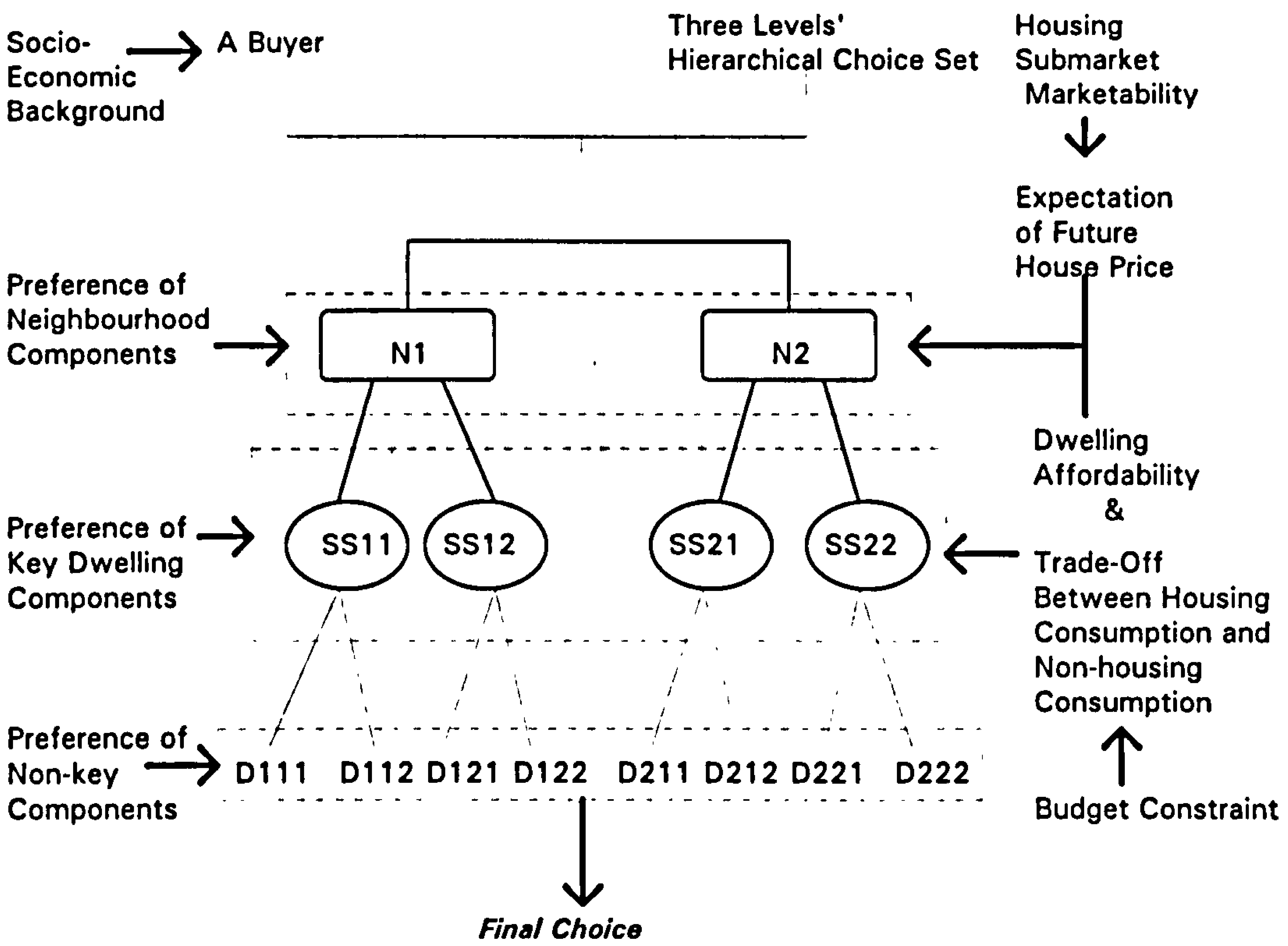
5.3.1 A Conceptual Framework

'*The complex nature of housing demand and households leads to more diverse household actions and hence to no universal pattern*' (Jones 1978(b), page 552), and therefore '*the choice decision of a household represents the outcome of a complex interaction of the psychological propensities, cognitive capabilities and social and economic pressures which affect the decision unit*' (Maclennan & William 1980, page 909).

Based on the above principle, a theoretical housing choice framework is set up (Diagram V(1)). In order to study this framework, an assumption is needed, which is a housing buyer is assumed to be a household unit, a consumer and a decision maker. He is a rational buyer and is aware of what kinds of dwellings which he prefers and can afford.

Diagram V(1)

The Conceptual Framework



Note: 1. N1 and N2 are the alternatives of neighbourhood submarkets. The dot-line box represents the choice for a neighbourhood submarket.

2. SS11..SS22 are the alternatives of sectoral housing submarkets. The dot-line box represents the choice for a sectoral housing submarket.

3. D111..D222 are the alternatives of individual dwellings. The dot-line box represents the choice for a dwelling.

Diagram V(1) provides a conceptual housing choice framework. It is built on a two level nested housing submarket structure. Therefore, each buyer faces a three level hierarchical choice set, namely, neighbourhood, dwelling sector and individual dwelling. In order to simplify the discussion, it is assumed that there are only two alternatives at each level of the choice set. In empirical analysis, the number of alternatives at each level are determined by the need of forecasting.

The framework outlines the dimensions of the factors which may influence housing choice behaviour, The main dimensions considered are: 1. household socio-economic background, e.g. the family life cycles; 2. housing submarket marketability which casts a buyer's expectation of the future housing price change; 3. household budget constraint which determines a buyer's dwelling affordability and his/her trade-off between the housing consumption and the non-housing consumption and 4. household housing preferences for the neighbourhood components, key and non-key dwelling components.

From each dimension, a number of factors which may influence the housing choice behaviour can be derived.

This framework can be applied to either an urban housing market or a regional housing market. However, the factors influencing housing choice behaviour will be different. In this study, the framework is applied to a regional owner occupier housing market. The following discussion will derive the factors corresponding to each dimension.

5.3.2 Factors Influencing Housing Choice Behaviour at Regional Level

1. Household socio-economic background. Household socio-economic background is determined by many factors. Among them, two factors are the most important in terms of housing choice: income and the family life-cycle. The influence of the household income as a budget constraint on the housing choice behaviour will be discussed later in this section. Here, the attention is paid to the effect of the family life cycle on the housing choice behaviour. A specification of the family life cycle was given in Chapter III. The significant differences in the preferences of the households' housing consumption are associated with their family components, like family size, age structure or marital status (David 1967). These will differentiate the households into the different stages of the family life cycle, and the households who are at the different stages of the family life-cycle will show the different housing choice behaviour. Therefore, a certain classification of the households in terms of their life-cycles is necessary when calibrating their housing choice behaviours. An empirical identification of the family life cycle is given in Chapter VII.

2. Household budget Constraint. Compared with most of the goods consumed by a household, buying a dwelling is one of the most expensive. The average housing price in a market is much higher than the average household annual income. In Lothian region, the average housing price (in 1989) is about 2.2 times as much as the average household annual income (Lothian Region Household Housing Survey, Appendices 6-2 & 7-2). On the other hand, the dwellings in the different housing submarkets have significantly different housing prices. Therefore, if the household income remains unchanged, a buyer's choice for a housing submarket is constrained by the submarket housing price. For example, the low income households are more likely to buy a dwelling in the sectoral submarket of small flat, and less likely to buy a dwelling in the sectoral submarket of larger house. If the requirement for the dwelling components is unchanged, the low income households are more likely to choose a dwelling from an inferior neighbourhood and less likely to choose one from a superior neighbourhood because of the budget constraint.

Because of the large gap between the housing price and the household income, most of the households have to join a mortgage system in order to buy a dwelling. This system allows a buyer to pay his/her housing expenditure by instalment.

Suppose that the amount of the deposit, mortgage rate and the total period of the payments are fixed, the amount of the monthly instalment for a buyer is determined by the housing price. A higher housing price results in a higher monthly instalment. On the other side, if a buyer's income is fixed, the more he/she pays on a dwelling, the less he/she can spend on other goods. Therefore, the housing consumption is related to the non-housing consumption. A buyer has to trade off between choosing a higher quality dwelling and/or choosing a higher quality of other goods. The final combination of these two kinds of expenditures should provide a buyer with maximum utility.

One possible indicator to reflect the influence of budget constrain and the trade-off is the ratio of the housing price to the household annual income. For most building societies or banks, this ratio is an important factor in determining how much money a buyer can borrow. When a buyer chooses a dwelling, it implies that he/she has already chosen the ratio. Choosing a higher ratio means a buyer prefers a better quality dwelling to a better quality of other goods, ceteris paribus. This ratio will be introduced into equation(4) to replace 'Gij'. If 'j' represents a housing submarket (either neighbourhood housing submarket or sectoral housing submarket), the ratio is the average submarket housing price over a household income.

3. Housing Submarket Marketability. For most of the households, buying a dwelling is a family investment. A buyer expects to gain more equity from selling the dwelling in the future. Previous analysis has show that the housing equity is mainly from the general housing price inflation (Maclennan &Tu 1995a). Therefore, the expected housing price increase in a submarket will increase the likelihood of a buyer choosing a dwelling from this submarket.

One of the conclusions in Chapter IV is that equilibrium submarket housing price is a strictly decreasing function of the submarket trade friction, or in other words, an increasing function of dwelling transaction velocity in the submarket. The latter represents submarket marketability. Reducing submarket trade friction will increase submarket dwelling transaction velocity, and hence, shorten the sellers' waiting time. Empirically, submarket marketability refers to how 'easy' a dwelling can be sold in a housing submarket at a good price. Therefore, submarket marketability can be measured by the submarket dwelling transaction velocity (β) defined in Chapter IV. This factor will enter equation (4) to replace one of the C_k(s). An empirical specification of the factor will be given in Chapter VII.

4. Household Housing Preference. A buyer's housing preference reflects how much a buyer prefers the components of the dwelling characteristics or the related neighbourhood characteristics. The more a buyer prefers the components, the more utility the buyer can obtain from the services provided by the consumption of the components.

A buyer's housing preference can be measured by the neighbourhood components and the dwelling components (See the classification in Chapter III).

At neighbourhood level, distance to the work place is a crucial factor to determine a buyer's location choice. In micro-economic theoretical and empirical analyses of housing demand, great emphasis has been placed on the importance of choice and the role of the journey to work as a determinant of residential location (e.g. Alonso 1964, 1978, Muth 1969, Jones 1979, Pollakowski 1982 and Quigley 1976, 1985). The empirical work (Quigley 1976, 1985) has suggested that it is unwise to ignore the effects of travel to work costs on dwelling location choice. A household will locate where the saving in transport costs from locating marginally closer to the employment centre is just balanced the additional housing expenditure which will be incurred.

Regional owner occupier housing market interacts with the regional labour market which has a nuclei submarket structure. This structure influences the household housing location choice in a number of ways. An example is given below to show the influence. In Lothian Region, Edinburgh is the central business district (CBD), and therefore it is the central residential area (CRA). East, West and Mid Lothians are the sub-CBDs and each is surrounded by a sub-CRA. If a buy works in the CBD, he/she can either choose a dwelling from the CRA by paying a higher house price but lower transport cost, or choose a dwelling from a sub-CRA but paying a lower house price but higher transport cost. If he works in the sub-CRA, e.g. East Lothian, he can either choose a dwelling from the CRA by both paying a higher house price and higher transport cost, or choose a dwelling from the sub-CRA by both paying a lower house price and lower transport cost. The choice depends on his/her preference for both the neighbourhood components and the transportation facilities if the dwelling components remain the same. Empirically testifying the influence of the nuclei labour market structure on the housing choice behaviour is important. Therefore distance to the work place will enter equation (4) to replace $C_k(s)$.

If other things are equal, a buyer is more likely to choose a dwelling from a superior neighbourhood rather than an inferior one. The quality of a neighbourhood can be measured by a number of components, for example, physical neighbourhood condition, neighbourhood amenities, neighbourhood school quality. The preference for a neighbourhood has a clear life cycle pattern. For example, the survey has shown that 33.3% young single households evaluate their physical neighbourhood condition as 'Excellent', compared with 68% oldest households (Table 14 in Appendix 7-2). A specification of these components is given in Chapter VII.

Dwelling components are: dwelling type, size, age as well as the interior dwelling structure (e.g. kitchen type). A large volume of empirical work has shown that the different households have the different preferences for these components (Boehm 1982, Quigley 1976, 1983,1985). The survey has shown that the average number of rooms chosen by young single households is 1.8 compared with 2.9 chosen by the households with dependent children (Table 13 in Appendix 7-2). These components will enter equation (4) to replace Ck(s).

The discussion above leads us to expect that (if other things remain equal):

1. The household housing preference has a clear family life cycle pattern.

2. A higher submarket marketability will increase the likelihood of a buyer choosing a dwelling from it.

3. A buyer prefers to live near to the work place, therefore, regional labour market structure shapes the regional household residential location choice behaviour.

4. A buyer's financial constraint limits himself to the housing submarkets which he can afford. A higher ratio of the average submarket housing price to his income may reduce the likelihood of the buyer choosing a dwelling from it.

These hypotheses are empirically examined in Chapter VII.

5.3.3 Modelling Strategy

Another implication emerging from this framework is that a buyer's choice for a dwelling can be split into two stages: stage one is to model a buyer's choice for a housing submarket (a sectoral housing submarket and the related neighbourhood housing submarket); stage two is to model a buyer's choice for a dwelling after selecting a sectoral housing submarket.

There are two advantages of this split. One is that the size of the choice set faced by each buyer at each stage is reduced and this can simplify the empirical calibration procedure. The other is that the budget constraint and the dwelling supply constraint can be considered in two stages separately. When a buyer chooses a housing submarket, his choice is strongly constrained by his financial budget. This is because the dwelling prices between the housing submarkets are significantly different (See the discussion in Chapter III). Although at this stage the dwelling supply also constrains a buyer's choice (this constraint may result in a buyer's real choice is not his maximum utility choice), the revealed preference data is still suggested to be used to reflect the buyers' housing submarket preferences. This can avoid a buyer over- or under estimating his housing preference, which is very likely to happen if stated housing preference is used.

After a housing submarket is chosen, the choice of a dwelling from the submarket will be less likely constrained by a buyer's financial budget. This is because the dwellings in the same sectoral housing submarket are only different in terms of non-key dwelling components (See the discussion in Chapter III), and their housing prices are not significantly different. Therefore, the dwelling supply constraint becomes important. The stated housing preference is suggested to be used to reflect a buyer's choice of an individual dwelling.

Actually, this two stage split model suits to most of the real world situation. Assuming that a household is looking for a dwelling, he will first have a picture in his mind about which area and what type of dwelling sector he prefers to home in. Then his housing search will help him to choose a specific dwelling finally.

The main disadvantage of the split model is that, the choice of a sectoral housing submarket may be also influenced by the non-key dwelling components (defined in Chapter III) in that submarket, but such influence is ignored by the split model.

Equation (4) is thus split into two:

$$P_{i,j} = P(V_1(G_{i,j}, C_{k1}..C_{km}, C_{n1}..C_{nl}) + \varepsilon_{ij} > V_1(G_{i,js'}, C_{k1}..C_{km}, C_{n1}..C_{nl}) + \varepsilon_{i,j'}) \quad (5)$$

$$\Pr_{i,j,d} = P(V_{d1}(C_{nk1}..C_{nkm}) + \varepsilon_{i,j,d} > V_{d1}(C_{nk1}..C_{nkm}) + \varepsilon_{i,j,d'}, \forall j_d \neq j_d') \quad (6)$$

where, $\Pr_{i,j}$ represents the probability of choosing a housing sector. $\Pr_{i,j,d}$ represents the probability of choosing a dwelling from a housing sector. $G_{i,j}$ is the budget constraint. C_{k1} to C_{km} are the key dwelling components. C_{n1} to C_{nl} are the neighbourhood components. C_{nk1} to C_{nkm} are the non-key dwelling components.

Equation (5) represents the probability of a buyer's choice for a sectoral housing submarket as well as the related neighbourhood. It denotes that such choice is constrained by his financial budget and influenced by his preference for the key dwelling components. The empirical calibration is suggested to be on the basis of the revealed housing preference. Equation (6) represents the probability of a buyer's choice for a dwelling after choosing a sectoral housing submarket, which is influenced by his preference for the non-key dwelling components. The empirical calibration is suggested to be on the basis of the stated preference.

The framework discussed in this section remedies the three disadvantages mentioned in Section 5.1. A consideration has been given to the possible influence of housing submarket structure on housing choice behaviour. Based on it, the factors which may influence a buyer's housing choice behaviour are selected in terms of their economic meaning. The split model also provides a framework for estimating housing choice behaviour by the combination of stated preference information and revealed preference information. The reason is that the choice of a dwelling from a sectoral housing submarket is less influenced by the buyer's budget, but more influenced by the dwelling supply, while the choice of a submarket is mainly constrained by a buyer's financial budget. Therefore the estimation of equation (5) will be based on revealed preference, but the estimation of equation (6) can be based on stated preference.

On the basis of this framework, Chapter VI will discuss two questions. One is how to select a suitable statistical model to empirically forecast a buyer's choice of a housing submarket and a buyer's choice of a dwelling after choosing a housing submarket; the other is how to design a questionnaire to collect the information needed. The empirical analysis will be given in Chapter VII.

CHAPTER VI METHODOLOGY AND DATA COLLECTION

6.1 Introduction

Chapter V provided a theoretical model of forecasting housing choice behaviour and showed that the housing choice behaviour can be modelled in two separate stages: the choice of a sectoral housing submarket and the choice of an individual dwelling in the submarket. From the model, a number of factors which may influence the housing choice behaviour, were derived and two different information collection techniques were suggested. This Chapter is aimed at selecting the suitable statistical models to empirically calibrate the housing choice behaviour (Section 6.2) and designing a questionnaire to collect the information needed (Section 6.3).

6.2 Discrete Choice Models : the MNL and the NMNL models

Modelling housing choice behaviour involves that the dependent variables are discrete values. Therefore, the discrete choice models should be used. A comprehensive classification of the discrete choice models is given below. This classification is a direct extension of the work of McFadden (1982).

Probit Models	Logit Models	Elimination Models
↓	↓	↓
Binominal Probit	Binominal Logit	Elimination By Aspects (EBA)
↓	↓	↓
Multinominal Probit Model (MNP)	Multinominal Logit Model (MNL)	Hierarchical Elimination By Aspect (HEBA)
	↓ ↘	↙
	Nested Multinominal Logit Model (NMNL)	

Among these models, the MNL and the NMNL models are the most widely used models in the housing choice analyses. This is mainly because they have much simpler functional forms and the parameters in the models have a direct link with the choice probability. All these models are derived from the random utility approach and they are different in terms of the different assumptions of the probability distribution of the error term ε_{ij} of equation (4) in Chapter V. There are several assumptions involved and each produces a different discrete choice model. These are discussed below.

The multinominal probit model (MNP) is derived by assuming the error terms, ε_{ij} j=1..J, have a joint multivariate normal distribution with zero mean and an arbitrary variance-covariance matrix Ω. This model was first proposed by Thurstone (1927) and has been applied to psychological-choice data by Bock & Jones (1968). Then it was further developed by Hausman & Wise (1978) and Daganzo (1980).

The main advantage of MNP over the MNL model is that it does not have the restrictions imposed by the IIA axiom of the MNL model (further discussion is given in the latter part of this section). The main disadvantages are:

1. the interpretation of the coefficients can not be done easily as the relationship between the choice probability and the coefficients is not direct;

2. a large number of alternatives is difficult to handle. Computation is the primary impediment to widespread use of the MNP model. Implementation of a fast and accurate approximation to the MNP probabilities remains an important research problem (Maddala 1983), especially in the housing market research where a dwelling is defined as a complex commodity with multiattributes. The number of dwelling alternatives will increase rapidly as more dwelling attributes are considered. For this reason the application of the probit model in housing choice is very limited.

The elimination By Aspect (EBA) model views an individual's choice as a process in which alternatives are screened from the choice set until a single alternative remains. It can be defined by the probability of transition from a set of alternatives to a subset. During this process each individual has his/her own criteria of elimination based on the known, identified, explanatory variables. The statistical model form was given by

Tversky (1972a,b). The advantage of the EBA model over the MNL model is similar to the MNP model. But this model suffers from two main criticisms.

First, the EBA model assumes that the aspects (in housing circumstances, 'aspects' are used to represent dwelling related components) which are shared by all alternatives do not affect the final choice probabilities. In my view, this may be a restriction for analysing housing choice behaviour as neighbourhood components shared by the dwellings certainly influence the final housing choice behaviours.

Second, the EBA model has a technical disadvantage similar to the probit model in that the computational burden will increase rapidly as the number of alternatives and different aspects increases (McFadden 1982) .

The hierarchical elimination by aspect model (HEBA) is an extension of the EBA model. It assumes a clear tree structure to reduce the number of alternatives faced by a buyer at each hierarchy. However the main drawback of the HEBA model is that it is a direct derivation of the EBA model, but not directly derived from random utility theory, and therefore the model lacks theoretical underpinning (Tversky & Sattach 1979). Besides, although it involves fewer parameters than the EBA model, the HEBA model is still computationally infeasible for large choice set and has not found many econometric applications (Maddala 1983)

The multinominal logit model (MNL) can be derived from equation (4) of Chapter V if the error terms ε_{ij}, $\forall j$ are assumed to satisfy the following assumptions:

1. ε_{ij}, $\forall j$, are mutually independent and are identically extreme-value distributed ('i' denotes an individual and 'j' denotes an alternative);

2. ε_{ij}, $\forall j$ are uncorrelated to the directly measured independent variables and related parameters of these variables;

3. ε_{ij} $\forall j$ have zero means;

4. ε_{ij} $\forall j$ are consistent with respect to maximisation, i.e. if ε_{ij} and $\varepsilon_{ij'}$ have the same distribution, then max $(\varepsilon_{ij}, \varepsilon_{ij'})$ must also have the same distribution.

This model and its extensions were developed by McFadden (1973, 1974, 1976a, 1978, 1979 and 1982). The functional form of the MNL model is:

$$\Pr_{ij} = \frac{\exp(v(\bar{x}_{ij}\beta))}{\sum_{j'=1}^{J}\exp(v(\bar{x}_{ij'}\beta))} \qquad (1)$$

(See McFadden 1982)

The MNL model relies on an important property, which is the ' Independence from Irrelevant Alternatives' (IIA) axiom. This means that the odds of j being chosen over j' is independent of the availability or attributes of alternatives other than j and j'. This property can be expressed as:

$$\frac{P_{ij}}{P_{ij'}}_{j,j' \in s} = \frac{P_{ij}}{P_{ij'}}_{j,j' \in c} \qquad (2)$$

where C is the full choice set and s⊂C is a subset of C.

In other words, for an individual 'i', the relative choice probabilities of choosing the alternatives j and j' are irrelevant of the existence of the other alternatives in the choice set. The axiom of IIA is a necessary and sufficient condition for applying the MNL model. The following example illustrates the essence of the IIA axiom when the MNL model is applied to a housing choice case.

Suppose that there are three dwelling alternatives:

h_1=small sized dwelling;

h_2=middle sized dwelling; and

h_3=large sized dwelling

Choice sets: $C=\{h_1, h_2, h_3\}$

$s=\{h_1, h_2\}$ and $s \subset C$

Suppose that the odds of choosing h_1 over h_2 from S are 2, thus:

$$\frac{P(h_1 / S)}{P(h_2 / S)} = \frac{\exp(U_{h1})}{\exp(U_{h2})} = 2 \qquad (3)$$

Again, suppose that the third dwelling 'h$_3$' is added to the set, forming the set C, and the IIA axiom holds, then

$$\frac{\Pr(h_1 / C)}{\Pr(h_2 / C)} = \frac{\exp(V_{h1})}{\exp(V_{h2})} = 2 \qquad (4)$$

From equations (3) and (4), it is obtained that

$$\frac{\Pr(h_1 / S)}{\Pr(h_2 / S)} = \frac{\Pr(h_1 / C)}{\Pr(h_2 / C)} = \frac{\exp(V_{h1})}{\exp(V_{h2})} = 2 \qquad (5)$$

Relating to the choice set s, $\Pr(h_1/S)+\Pr(h_2/S)=1$ and combining with equation (3),

$\Pr(h_1/S)=0.67$ and (6-1)

$\Pr(h_2/S)=0.33$ (6-2)

Assuming that

$$\frac{\Pr(h_1 / C)}{\Pr(h_3 / C)} = \frac{\exp(V_{h1})}{\exp(V_{h3})} = 1.5 \qquad (7)$$

Relating to the choice set C, $\Pr(h_1/C)+\Pr(h_2/C)+\Pr(h_3/C)=1$ and combining with equations (5) and (7),

$Pr(h_1/C)=0.46$ (8-1)

$Pr(h_2/C)=0.23$ (8-2)

$Pr(h_3/C)=0.31$ (8-3)

The above results show that if the IIA axiom holds, an individual's relative preference for any two dwellings, h_1 and h_2, should not be influenced by the existence of the third dwelling, h_3. Although the choice probability for each dwelling has changed.

Although the MNL model has a very simple model form and the coefficients have direct relation to the choice probabilities compared with the other alternative discrete choice models, it suffers some criticisms, mainly the possible violation of the IIA axiom, particularly in a housing choice case. Quigley (1983, 1985) argues that the IIA axiom is violated in a housing choice circumstance.

However if a buyer is a rational buyer, satisfying the axiom of completeness (see Chapter V, the violation of the axiom of IIA can be avoided. This is mainly because a rational buyer can rank the dwellings properly; and after housing search, each buyer is assumed to have obtained full market information. As a result, each buyer will be able to judge the relative utility he/she can obtain from two dwellings. This implies that the axiom of IIA can be satisfied theoretically although empirically a buyer may not always behave rationally. Hausman and McFadden developed a statistical diagnostic to test the axiom of IIA (Hausman and McFadden 1984). The principle of the test is to estimate if there is any significant difference between the coefficients of the independent variables estimated by the full choice set and the coefficients estimated by any one of the subsets. However, empirically, this test is only applicable to the smaller sized choice set. In this study, there are 63 alternatives in the full choice set, and a huge number of subsets are derived. This may cause an empirical calibration problem and, therefore, limits the use of the method.

However, one of the assumptions of the MNL model is easily violated in the housing choice case and this is the assumption of independent error terms. This is mainly because, in the MNL model, the independent variables $\bar{x}_j$ include the neighbourhood components shared by the dwellings in the same neighbourhood. The unmeasured part of the neighbourhood components are classified into the error terms, which means that ε_{ij} and $\varepsilon_{ij'}$, if j and j' are in the same neighbourhood, share the same unmeasured factors. They are thus not independent, and the assumption of the error terms is violated. This will introduce biases to model estimation.

In order to avoid this drawback but take the advantage of the model, the NMNL (nested multinominal logit) model has been developed (McFadden 1978).

The NMNL model is an empirical generalisation (a mathematical functional change) of the MNL and the HEBA models (McFadden 1978, 1982). It is computationally tractable for a large choice set and involves the sequential use of the MNL program. McFadden (1978) proved that the model could be derived from random utility theory by assuming that 'ε(s)' have a generalised extreme value distribution. This derivation remedies the drawback of the HEBA model and avoids the assumptions used in the MNL model.

A simple case is illustrated below based on Diagram III(1) in Chapter III. A buyer faces four alternatives. These four alternatives are split into two groups: two neighbourhood housing submarkets and two sectoral housing submarkets within each neighbourhood. The forecasting model will be able to calculate the choice probability for each of the four sectoral submarkets as well as for each of the two neighbourhoods.

Both the MNL model and the NMNL model can be used for the empirical calibration. The MNL model will derive all the choice probabilities simultaneously and the choice probability of each neighbourhood is a simple aggregation of the probabilities of the sectoral housing submarkets. However, the NMNL model will calculate the choice probabilities sequentially.

The functional form of a two stage nested logit model can be expressed as:

$$P_{l/k} = \Pr(l/k) = \frac{\exp(v(\vec{x}_{kl}\beta))}{\sum_{l'=1}^{L}\exp(v(\vec{x}_{kl'}\beta))} \tag{9}$$

$$\Pr_k = \Pr(k) = \frac{\exp(v(\vec{x}_k\alpha)) + (1-\sigma)I_k}{\sum_{k'=1}^{K}\exp(v(\vec{x}_{k'}\alpha) + (1-\sigma)I_{k'})} \tag{10}$$

$$I_k = Ln(\sum_{l'=1}^{L}\exp(v(\vec{x}_{kl'}\beta))) \tag{11}$$

The choice probability for alternative kl ,which represents a sectoral housing submarket, is the product of $Pr_{l/k}$ and Pr_k

$$Pr_{kl} = Pr_{l/k} * Pr_k \tag{12}$$

where: k denotes the neighbourhood housing submarket, l denotes the sectoral housing submarket.

I_k is named as the inclusive value. It captures the information of the sectoral housing submarkets nested in one neighbourhood. For the ease of discussion, the subscript 'i' denoting an individual is omitted from the model.

When $1-\sigma=1$ ($\sigma=0$), the nested logit model is reduced to the form of the MNL model. This implies that this coefficient can be used for testing if the alternatives in the choice set satisfy the IIA axiom.

Compared with the MNL model, the NMNL model has three very distinct advantages:

1. It allows the residual terms in the random utility function to be correlated. This property means that the NMNL model has a variety of applications.

2. Theoretically the model provides a statistical test of the IIA axiom. If $(1-\sigma)$ is significantly different from 1, the axiom of IIA is violated.

3. The hierarchical structure of the model reduces the number of alternatives handled at each hierarchy, making the computation easier.

However it has two main disadvantages:

1. A necessary and sufficient condition for a NMNL model to be consistent with random utility theory is that the coefficient of the inclusive value should lie in the unit interval (McFadden 1978). However, the statistical distribution of 1-σ is still unclear. This creates the problem of empirically testing it. Particularly, there is no statistical diagnostics available to test if the true value of 1-σ is within a unit interval.

2. Economically, the choice of a neighbourhood '*k*' is influenced by the neighbourhood (spatial) components as well as the aggregate condition of the dwellings in the neighbourhood. The functional form of the NMNL model implies that the latter influence is measured by the inclusive value (I_k) in the model. A suspect is raised if this value can accurately convey the information of the dwelling sectors to the neighbourhood level. For example, if a buyer is interested in the small flats located in one neighbourhood, the quality of larger house will have less influence on the buyer than the quality of the small flats. The NMNL model does not emphasis this difference.

3. The precondition of using the NMNL model is that an estimation sequence has to be assumed. A key question is if the assumption influences the estimation results? For

example, is there any empirical difference if the estimation sequence is assumed as that neighbourhood is in the first level and dwelling sector is in the second level or the sequence is the opposite? This disadvantage together with the second one implies that the restrict of the functional form might introduce estimation biases to the choice probability.

Based on the above discussions, using either the MNL model or the NMNL model may bring biases to the empirical results. Briefly, the bias caused by using the MNL model is from two sources:

1. The possible violation of the IIA axiom implied by the model.

2. The assumption of independent error terms is violated in the housing choice case.

The bias caused by using the NMNL model is from two sources:

1. the restrictions of the NMNL model functional form: the assumptions of the estimation sequence and the inclusive value.

2. there is not a satisfactory statistical test to test if the condition of $0<1-\sigma\leq1$. holds. Therefore, the theoretical foundation of the NMNL model is not sound.

The above discussion shows that theoretical, both models have their merits and limitations when applied to a housing choice case. Therefore, which one should be chosen will depend on the empirical results. In other words, the model empirically creating less biases should be used. Two statistical diagnostics are suggested to judge the quality of the model. One is the Pseudo-R^2, the other is the significance of the coefficients. The mathematical specification of these statistical diagnostics are given in Appendix 6-1. The empirical comparison is given in Chapter VII.

In Chapter VII, both models will be used to calibrate a buyer's choice of a sectoral housing submarket as well as the related neighbourhood housing submarket and the MNL model will be used to calibrate a buyer's choice of a dwelling given the choice of a sectoral housing submarket. This is because the choice for a dwelling given a sectoral housing submarket only involves one level choice.

6.3 Outline of Data Collection

6.3.1 Data Collection Procedure

As an initial step, the existing data bases were investigated to establish what data already existed. The ESPC (Edinburgh Solicitors Property Centre) database and the Register of Sasine database were used. The information in the ESPC database includes the asking price and the sale price of a dwelling, the offer type and the sellers' real waiting time in the market. The information in the Register of Sasine includes the sale price, the dwelling address and the buyer's name. They were found to provide only part of the required information, e.g. the housing price and the dwelling address. Further data collection was deemed necessary because the discussion in Chapter V suggests that the following data is required: households socio-economic backgrounds, dwelling and neighbourhood related components.

Two major data collection methods were considered with the view to supplementing the existing databases:

1. Mail questionnaires (the respondent records his answer on a printed schedule of questions);

2. Structured interviews (an interviewer administers a printed schedule of questions).

Each of these methods has distinct advantages and disadvantages. In particular there is a strong association between the cost (time and finance) and quality of the information with both tending to increase as one moves from method (1) to method (2).

The method of mail questionnaire was selected as a better method for this study (The questionnaire used is presented in Appendix 6-1). The reasons for this selection are:

1. Low financial cost and quick responses. Compared with the structured interview method, mail questionnaire has a much lower financial cost and a much shorter response time.

2. Confidential. The household survey involves asking the respondents private information, e.g. household income. A direct home interview may affect the chance of the respondent providing the correct information. Contrarily, the anonymous mail letter can give the respondent a confidential feeling and reduce the bias.

The main disadvantages of the mail questionnaire are the relative low response rate and the possibility of inaccurate answers. The first disadvantage requires that the selection of the sample size should consider the influence of the response rate. The second disadvantage requires that it is very necessary to 'clean' the collected data, i.e. to omit any unreasonable returns. The unreasonable returns can be identified by testing if some logic relationships between the questions are satisfied by the response, for example, the logic relationship between the household income and the occupation as well as the age of the head of the household; the relationship between the housing price and the dwelling type, size and location. Based on the above discussion, the data collection procedure involved:

1. Identifying the survey population (Section 6.3.2);

2. Choosing a suitable information collection technique to design the questionnaire (Section 6.3.3);

3. Selecting the sample size. A pilot survey was used in order to obtain some pre-knowledge of the likely response rate (Section 6.3.4);

4. Controlling the response rate. This is undertaken by re-sending questionnaires to the same address after one or two weeks (Section 6.3.4).

5. Evaluating the data quality, e.g. testing and omitting the unreasonable returns, checking the representative of the sample (Section 6.3.4).

6.3.2 Defining the Research Area

To investigate household housing choice decision making process, the Lothian Region housing market area was selected as the research area (see Map One in Appendix 7-1). The reasons are:

1. Lothian Region is defined as a travel to work area by Coombes et al (1982). Edinburgh is the Central Business District (CBD) with East, West and Mid Lothian as travel to work districts. The dwelling types and prices are different across the districts. Therefore, this geographic pattern provides a good foundation for identifying a nested regional housing submarket structure and investigating the buyers' preferences for a each housing submarket.

2. The theoretical model in Chapter V has shown that submarket house price is an important factor influencing a buyer's choice and a precise house price information is required for modelling. The Register of Sasine database in Lothian Region records exact dwelling transaction price as well as dwelling address, which provides a good condition for questionnaire survey.

Two sample populations were considered as possible objective populations:

1. a random sample from the entire population;
2. a random sample from recent movers.

In the first case, people who have lived in the region for some length of time are grouped with the people who have only recently bought a dwelling in the region. The main drawback of using this sample for modelling is that the recent movers and the non-recent movers may have faced different dwelling price levels because of the housing price inflation. This makes it difficult to compare the submarket housing prices. Therefore, the recent movers are selected as the sample population in this study. Cross-sectional data are used. Practically, all the samples bought their dwelling in the same year (in 1989).

6.3.3 Questionnaire Design

Chapter V specified the information needed to build the model. A questionnaire is needed to obtain this information. As pointed out in Chapter V, the revealed preference data is suitable to calibrate a buyer's choice for a sectoral housing submarket and the stated preference data is suitable to calibrate a buyer's choice for a dwelling after choosing a sectoral housing submarket. Therefore both methods were used to design the questionnaire. An explanation of the two methods is given below.

Traditionally, the analysis of housing choice has been based on 'revealed preference' data (i.e. Quigley 1985, Blackley & Ondrich 1988). That is, the choices and the decisions have actually been made in the market place. The revealed preference (RP) data requires an observation of what was chosen (or how often it was chosen) and what was rejected (or how often it was not chosen), plus actual measurements of associated attributes and interpersonal factors. Models are calibrated directly using these data, and the statistical tests determine their' adequacy'.

The true validity of a model, however, lies in its ability to reproduce other choices which do not draw from the calibration sample or an associated 'hold out' sample (Louviere 1983). The main limitations of the revealed preference are connected with the high survey costs, and lack of control in some choice alternatives which may not yet exist in the real choice set but may be preferred by the buyers. In other words, the influence of the supply constraints on the housing choice behaviour is ignored.

As an alternative, the stated preference methods (SP) have been developed, especially in market demand analysis. A definition of SP given by Green & Srinivasan (1988) is that SP data are collected in the form of preferences or choices from the hypothetical alternatives. These hypothetical alternatives are pre-specified in terms of different attributes. For this reason, SP is also called Laboratory-Simulation analysis or conjoint analysis. The main advantages of the stated preference method are:

(1) The approach can directly study and evaluate products, services or situations which are qualitatively or quantitatively different from those which are commonly encountered. In a housing choice circumstance, using this kind of information relaxes the housing supply constraint.

(2) Each individual can respond to several different hypothetical choice situations; this increases the efficiency of data collection and in some cases can provide enough

data to estimate the utility function for each individual (eg, by rating response). In other words, the environment of choice can be precisely specified requiring a decision which allows straight forward identification of effects and large quantities of relevant data can be collected at moderate cost.

Therefore, the SP approach is a method which is easier to control, e.g. the researcher can control the potential sources of bias and so reduce model misspecification by appropriate design techniques before data collection, more flexible, e.g. the design can cope with broad ranges of choice attributes and reduce intercorrelation between attributes and cheaper to apply than the RP method.

The major disadvantages of using SP are both validation problems:

(1) It is important to know whether the models calibrated on the SP data 'agree with those calibrated on the RP data' (Bates 1988). That is, people (in the future) may not necessarily do what they say, but this only becomes serious where research undertaken to estimate demand levels uses only SP data.

(2) People may not be able to evaluate their preferences properly on the measurement scale being used. For example some people may overstate their response under experimental conditions. Especially in a housing choice circumstance, the respondent may ignore the budget constraint when answering SP questions. This results in some respondents misestimating their housing demand preference structure.

In terms of this study, a combination of SP and RP data may offer an attractive solution to investing housing choice behaviour.

Firstly, it has been shown (Chapter V) that the information needed to calibrate housing choice behaviour by submarkets should be based on the revealed preference data only. This is because the budget constraint is an important factor influencing a buyer's choice for a submarket.

Secondly, the empirical calibration for a buyer's choice of a dwelling given the housing submarket is based on both kinds of information. Therefore the results from both RP data and SP data can be compared. The influence of the dwelling supply constraint can be investigated (Chapter V).

Appendix 6-2 gives a full discussion of questionnaire structure.

6.3.4 Determining the Sample Size and Evaluating Data Quality

According to the Register of Sasine database, there were 22,139 dwelling transactions in Lothian Region in 1989, which was the 11% of the total regional owner-occupier dwelling stock.

A pilot mailing questionnaires were sent out to 150 households in order to estimate the response rate and test the questionnaire. The response rate was 31%. This number was used to estimate the total required sample size. Considering the data size requirement in empirically calibrating the discrete choice models by splitting samples, information from approximately 700 households was needed. Considering the expected response rate, 2000 questionnaires were sent out and 500 kept as reminding questionnaires. If the response rate obtained from the first wave was very low in some areas, the reminders were needed for a second wave.

A structured, random sampling technique was used to select the respondents' addresses. Lothian Region has four districts: Edinburgh, West Lothian, East Lothian and Mid-Lothian. Almost 80% of the owner occupier dwellings are located in Edinburgh, therefore, majority of the dwelling transactions occur in Edinburgh. In order to increase the representative of the sample, the sub-sample size of each district was made proportional to the owner-occupier dwelling transaction (in 1989) of each district. After determining the subsample size, a random sampling technique was applied to each district.

Of the initial 2000 questionnaires, 296 were sent back due to 'wrong' addresses and the response rates in Edinburgh and the East Lothian area were low. As a result, another 500 new addresses were selected. 100 were sent to East Lothian and 400 were sent to Edinburgh. Totally 810 respondents completed the questionnaire. The response rate is about 36.7% (the number of returns over the number of questionnaire receivers which is equal to (810/(2000-296+500)). However, about 113 respondents' answers were bad quality and omitted (e.g. some of the respondents erased their address in order to keep their information confidential, or some of them gave wrong information). As a result, the actual, effective response rate of approximately is 32%.

In the empirical analysis of Chapter VII, 710 sample points are actually used. The extra 13 sample points are the artificial sample points created for the purpose of modelling. Lothian Region owner occupier housing market is divided into 7 neighbourhood and 36 sectoral housing submarkets (Chapter VII). In some housing submarkets, i.e. the submarket of large house located in the central Edinburgh, there was few dwelling transactions in 1989. As a result, none of the sample points obtained was from these submarkets. However, the empirical model requires at least one sample point for each alternative. Therefore some artificial sample points have to be created. The sample has a good representative (see Table VI(1) and VI(2)).

Table VI(1) Sample Representative (1)

Location	Number of Dwellings (c)	Number of Dwellings (Sa)	Number of Dwellings (Sm)	Average Housing Price (Sa)	Average Housing Price (Sm)
Edinburgh Area	157,423 (79.1%)	16,603 (75%)	488 (69%)	£52,347	£57,215
Outside Edinburgh	41,547 (21.9%)	5,536 (25%)	222 (31%)	£47,771	£47,275
Lothian Region	198,970 (100%)	22,139 (100%)	710 (100%)	£51,202	£54,112

Note: (c) represents the 1989 owner occupier housing stock (census data).

(Sa) represents the 1989 Register of Sasine data (the number of dwelling transactions).

(Sm) represents the 1992 randomly sampled survey data from 1989 Sasine's database.

Table VI(1) gives a broad comparison of the sample distribution and the average housing price distribution. The results show that the average housing price from the sample is very close to the average population housing price. Although the sample proportion in Edinburgh is lower than the population proportion, the difference is not significant (7 percentage point lower). The sample rate in Edinburgh is 2.9% and in other areas, it is 4% compared with the average sample rate is 3.2%.

Table VI(2) Sample Representative (2)

	Register of Sasine	Sample
Livingston Area	42%	40%
M.Lothian & Linlithgow Areas	30%	35%
E. Lothian Area	28%	25%
Total	100%	100%
Edinburgh-1	7%	14%
Edinburgh-2	27%	22%
Edinburgh-3	42%	35%
Edinburgh-4	24%	29%
Total	100%	100%

Table VI(2) compares the population distribution with the sample distribution across 7 neighbourhood housing submarkets. The identification of these housing submarkets are given in Chapter VII. The data shows that the sample distribution is very close to the population distribution in East, West and Mid- Lothian, but in Edinburgh, especially, in the central Edinburgh (Edinburgh-1), the sample proportion is much higher than the population proportion. The bias partly comes from the creation of the artificial data, partly comes from a higher response rate obtained from this area. The Edinburgh central area is favoured by young people who are economically active. The survey shows that this kind of respondents provides a good response rate. However this bias is not serious as the sample distribution in the other three Edinburgh housing submarkets is very close to the population distribution.

The above discussion shows that, although some biases exist in the sample, they are not serious. Therefore, the empirical housing choice model will be calibrated and tested on the basis of these 710 sample points. The results are presented in Chapter VII.

CHAPTER VII EMPIRICAL RESULTS

7.1 Introduction

Chapter V provides a conceptual framework of modelling household housing choice behaviour. On the basis of this framework, Chapter VI identified two statistical models which were suggested to be used in the empirical calibration of the framework. This chapter is aimed at presenting and analysing the empirical results.

Section 7.2 empirically classifies the buyers into four stages of the family life cycle and identifies seven neighbourhood housing submarkets and nine sectoral housing submarkets in each neighbourhood. Three non-key dwelling components are selected to differentiate the dwellings in each sectoral housing submarket. An empirical (Lothian Region) nested housing submarket structure is built up on the basis of the theoretical discussion in Chapter III. Section 7.3 specifies the independent variables used in the empirical model. These variables are derived from the theoretical model provided in Chapter V. Section 7.4 analyses the empirical results of housing choice by submarkets. An empirical comparison of the suitability of the MNL model and the NMNL model when applied to a housing choice case is given. Section 7.5 analyses the empirical results of housing choice by dwellings given a sectoral housing submarket.

The results in these two sections are compared with the previous housing choice literature (See the discussion in Chapter II), and provide empirical evidence to support the theoretical discussions (conclusions) in Chapters IV to VI.

7.2 Data Overview

7.2.1 Classifying Households by the Family Life Cycle

The theoretical model in Chapter V explored that the households who were in the different stages of the family life cycle exhibited different housing choice behaviour. Therefore the household socio-economic background should be selected as the explanatory variables.

Limdep 6.0 is used to empirically calibrate the discrete choice MNL and NMNL models. The calibration procedure does not allow (in terms of technique) the household information, i.e. age or family size, to enter the model directly. An alternatives is to group the households by their socio-economic backgrounds. In this study, the households is classified into the different stages of the family life cycle based on the theory introduced in Chapter III.

The households in the sample is grouped into four stages of the family life cycle (See Table VII(1)). This classification is derived from the approach of the Minimal Household Unit (Ermisch & Overton 1985) discussed in Section 3.3 of Chapter III.

Table VII(1)

Identification of the Family Life Cycle

Life-Cycle Stages	Description	Sample Size	Percentage
Stage I	Young Single age below 44	125	17.6%
Stage II	Young Couple aged below 44	154	21.7%
Stage III	With Dependen Children	329	46.3%
Stage IV	Older couple o Single, aged ove 45	102	14.4%
Total		710	100%

Source: 1992 Lothian Region Household Housing Survey (Appendix 6-2)

The average household income and the average house price chosen by the buyers differ over the family life-cycle as is clear from Table VII(2) below:

Table VII(2)

The Average Household Income and Dwelling Price Across the Family Life Cycle

Life-Cycle Stage	Ave. Household Income (£)	Ave. House Price (£)	Ratio of Price/Inc
I	17686	36604	2.07
II	28065	48152	1.72
III	25049	58274	2.33
IV	19674	60920	3.09
All	23634	52500	2.22

Source: 1992 Lothian Region Household Housing Survey (Appendix 6-2)

The above table shows that the housing price selected by a household increases with the family life cycle, but is inconsistent with the life cycle change of household income. The reason is given below.

For most of the households in UK, buying a dwelling is an important family investment. The home owners expect to accumulate their housing wealth through house price inflation. When they move (on average, every 8 years a UK home owner moves once), majority of the housing equity, which they have obtained from the sale of their previous dwelling, is re-deposited into their new house. As most of the UK home owners start their housing career at their late 20s, a higher stage of the family life cycle implies that a household may own more housing equity (Maclennan & Tu 1995a, Tu & Maclennan 1995). Therefore they can afford a higher deposit or a more expensive dwelling. However, within the same stage of the family life cycle, if other things remain unchanged, income is a very important financial constraint in buying a dwelling as discussed in Chapter V.

Their housing preferences are different over the family life cycle. an example is given in Table VII(3).

Table VII(3)

Housing Preferences Over the Family Life Cycle

Life-Cycle Stage	Ave. Dwelling Size	Percentage of Flats
I	2.8	81.1%
II	3.9	44.6%
III	4.9	25.2%
IV	4.2	33.7%
All	4.2	40.6%

Note: Dwelling size is measured by the total number of rooms except the number of bathrooms and the number of kitchens. Source: 1992 Lothian Region Household Housing Survey (Appendix 6-2)

Table VII(1) shows that almost 46.3% of the buyers are households with dependent children. On average, these buyers choose a higher ratio of price to income (Table VII(2)) and prefer the bigger sized houses (Table VII(3)). This is because this group of people have a larger size family. On the other hand, 17.6% of buyers are single person households in stage I. They choose a lower ratio of price to income and prefer to buy smaller sized flats. This is because they have the smallest family size and may prefer to spend more money on other goods. Thus, the buyers have different housing preferences over the family life cycle.

7.2.2 Identifying the Choice Set

The theoretical model in Chapter V exhibits that, in a local housing market, a buyer faces a three level choice set. The first level alternatives are the neighbourhood housing submarkets; the second level alternatives are the sectoral housing submarkets; and the third level alternatives are the individual dwellings. An empirical dwelling choice set needs to be identified in order to model housing choice behaviour.

The information needed to empirically identify this hierarchical housing choice set is from 1989 ESPC housing price data, the Register of Sasine data and the questionnaire survey. The procedure takes the following three steps: the identification of a neighbourhood housing submarket; the identification of a sectoral housing submarket and the identification of a specific dwelling. The identification of a housing submarket is undertaken by grouping the dwellings into different product groups. These product groups are simply assumed as the housing submarkets in the following discussion although according to the definition of housing submarket in Chapter III, a hedonic analysis is needed to further classify theses product groups into different housing submarkets. This approximation will not influence the empirical analysis as the estimation is based on the average housing price rather than the hedonic housing prices.

Identification of the neighbourhood housing submarkets in Lothian Region.

1. In Edinburgh District, the dwellings are first classified into each District ward. Each ward is treated as a minimum unit. These wards are then grouped together into neighbourhoods using cluster analysis. Three factors are selected in the cluster analysis. They are the average housing price in each ward, the percentage of the detached- or semi- detached houses and the percentage of the flats in each ward. Based on these criteria, 62 District wards in Edinburgh are grouped into four neighbourhoods in terms of the similarities of the three factors. The data used are 1989 ESPC data. In this database, district ward information is provided for each individual dwelling.

2. In East, West and Mid Lothian Districts, the dwellings again are first classified into the District wards. The wards are then grouped by the average housing price in each ward. This gives three neighbourhoods constructed outside Edinburgh district. The data used are from the 1989 Register of Sasine database. Although this database doesn't provide district ward information directly, it has to be adopted here since the ESPC data does not cover these districts.

The neighbourhood identification is based on Edinburgh and outside Edinburgh separately (See Diagram VII(1)). The reason for a separate classification is that all the three neighbourhoods outside Edinburgh are travel to work areas. As a result, even if one of these housing submarkets has a similar average housing price to a neighbourhood housing submarket within Edinburgh, they should not be grouped together because their hedonic functional form may be different.

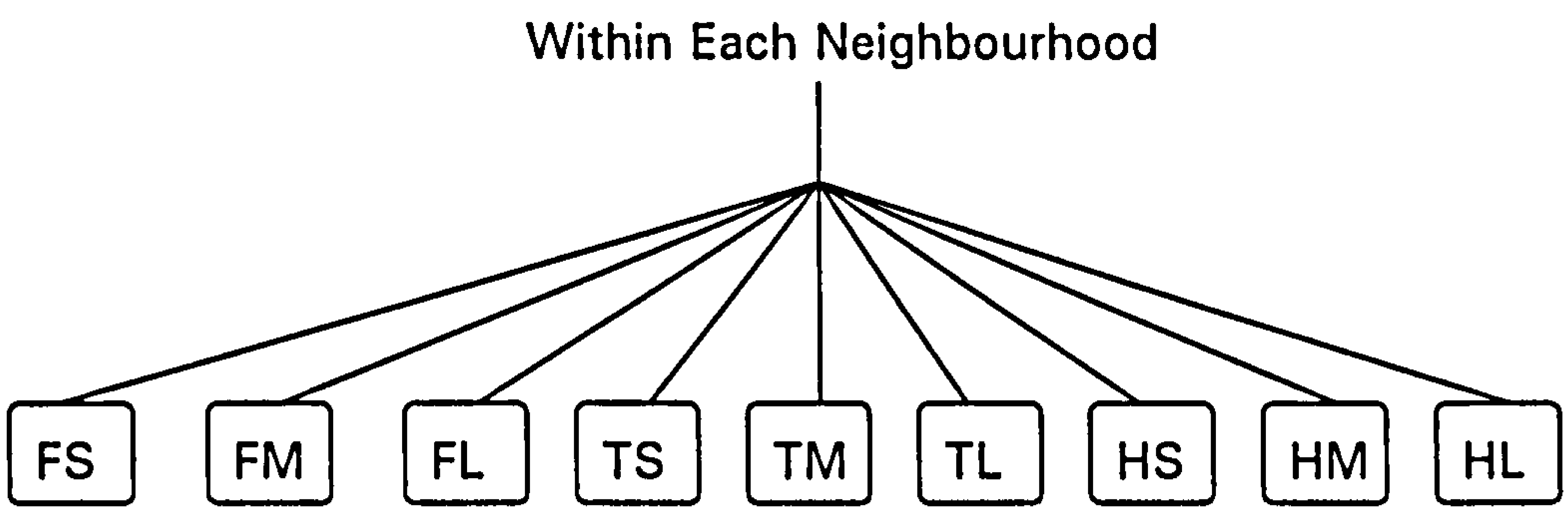
Identification of the sectoral housing submarkets in Lothian region.

Sectoral housing submarkets are constructed from two dwelling related characteristics: dwelling type and dwelling size. The data used are from the questionnaire survey since neither the ESPC data nor the Register of Sasine include dwelling type information. Dwelling types are differentiated by three key components: semi-detached or detached house, main door flat or terraced house, and flat; Dwelling size is differentiated by three levels of size: two or less bedrooms, three or four bedrooms and five or more bedrooms. Using this classification nine sectoral housing submarkets are identified, and the average house prices vary across these sectoral housing submarkets within each neighbourhood (See Diagram VII(2)).

Diagram VII(1) and VII(2), together, illustrate an empirical (Lothian Region) nested submarket structure.

Diagram VII(1)

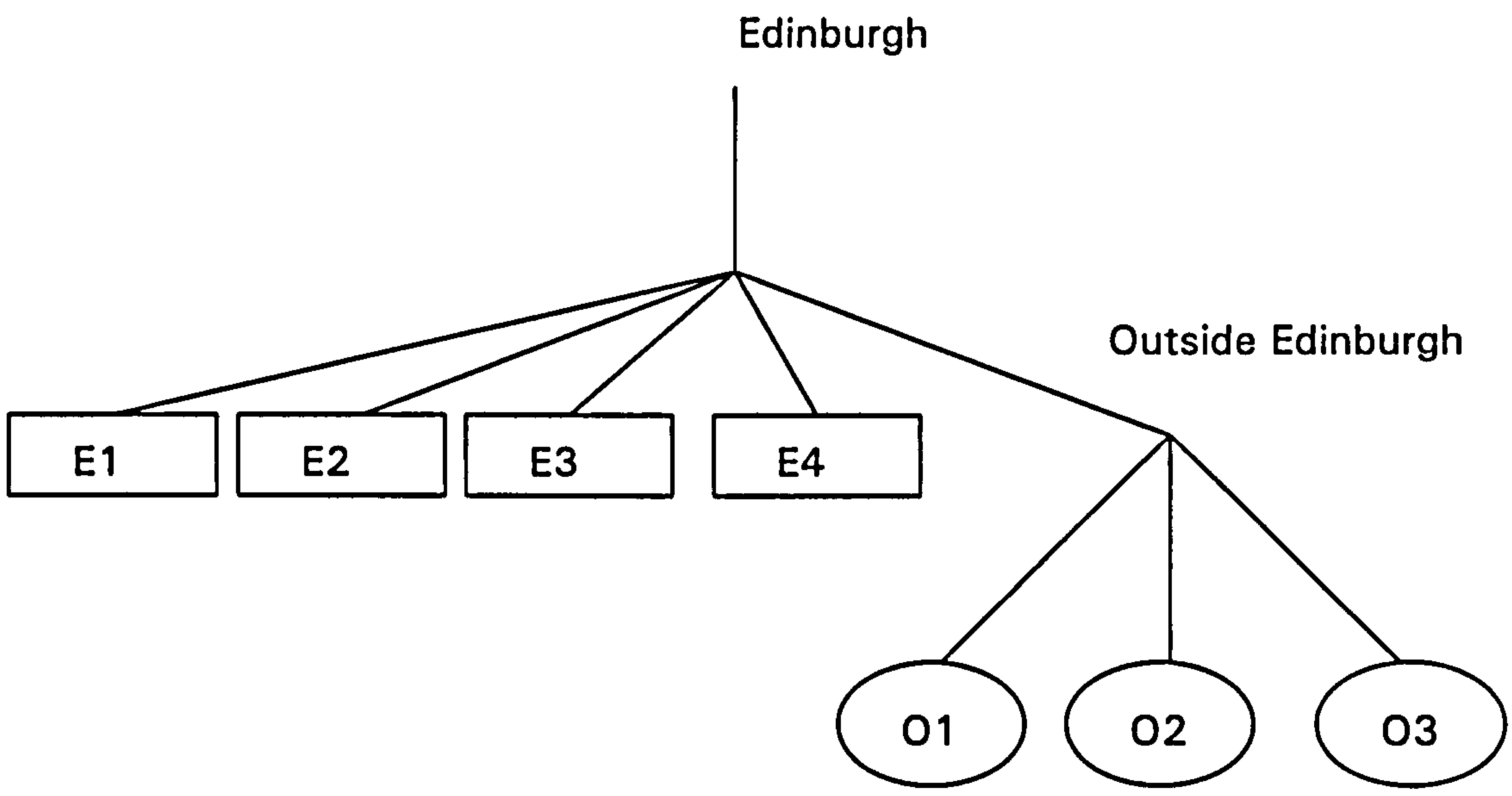
Lothian Region Sectoral Housing Submarket Within Each Neighbourhood



where F = flat; T = main door flat or terraced house; H = detached or semi detached house
S = two or less bedrooms; M = three or four bedrooms;
L = five or more bedrooms.

Diagram VII(2)

Lothian Region Neighbourhood Housing Submarkets



Where: E = Edinburgh and O = outside Edinburgh

Some more information about the identification of Lothian Region Housing submarket is givens in Appendix 7-1.

Identification of a dwelling in a sectoral housing submarket

The discussion in Chapter V shows that the dwellings in a sectoral housing submarket are differentiated by the non-key dwelling components (See Chapter III). The discussion below will give an empirical classification based on three non-key dwelling components. They are: Kitchen Type, Central Heating and Private Garden. This is because over 94% of the buyers think that Kitchen Type, Central Heating and Private Garden are the most important non-key dwelling components (see Table 2 in Appendix 7-2).

These three components produce eight alternatives (See Table VII(4)). In the table, 'Kitchen' denotes Kitchen Type (0=small kitchen, 1=large kitchen). 'Central Heating' denotes the facility of central heating (1=has it, 0=without it). 'Garden' denotes private garden (1=has it, 0=without it).

Table VII(4)

Identification of Each Individual Dwelling Within a Sectoral Housing Submarket

	Alt-1	Alt-2	Alt-3	Alt-4	Alt-5	Alt-6	Alt-7	Alt-8
Kitchen	1	1	1	0	1	0	0	0
Central Heating	1	1	0	1	0	1	0	0
Garden	1	0	1	1	0	0	1	0

The discussion in Chapter V suggests that modelling household housing choice for non-key dwelling components should be based on the stated dwelling preference. In the empirical model, both revealed and stated preference data are used. The household housing survey (Appendix 6-2) provides both information. The revealed preference is from the buyers' real choice for the non-key dwelling components. The stated preference information is from the buyers' ranking for six non-key dwelling components including the above three. Therefore a transformation from the ranking data to the choice data is needed. The transformation follows that if a buyer ranks these three as the top three important components among the six, the buyer will choose alternative one; if among the top three ranks, there are only the components of large kitchen and central heating, then alternative two will be chosen; if among the top three ranks, there is only the component of large kitchen alternative five will be chosen, etc..

The above discussion shows that, in the Lothian Region private owner occupier housing market, a housing buyer faces a three level hierarchical choice set, which is: 7 neighbourhood housing submarkets, 9 sectoral housing submarkets in each neighbourhood and 8 types of dwelling in each sectoral housing submarket (Appendix 7-1).

The empirical analysis in Sections 7.4 and 7.5 will be based on this choice set. Before commencing these analysis, the selection of the independent variables to be used in the model are given below.

7.3 The Selection of the Independent Variables

As required by the estimation procedure in Limdep 6.0, the independent variables needed for empirically modelling a MNL or a NMNL model should be the variables describing the natures of the alternatives. The data structure is given in Appendix 7.3. The following discussion will focus on the selections of the these (explanatory) variables. The selection is theoretically based on the conceptual framework discussed in Chapter V. The mathematical specifications of the variables are presented in Appendix 7-4.

1. The alternatives are the neighbourhood housing submarkets.

For a specific buyer, five factors may influence his choice for a neighbourhood.

(a) Financial budget constraint *(NRPI).* As discussed in Chapter V, if other things remain unchanged, a lower income household is more likely to choose a neighbourhood with lower average housing price. This is because the same type of the dwellings has different dwelling prices if located in the different neighbourhoods. If income is fixed, buying a more expensive dwelling implies that the buyer has to reduce non-housing consumption. Therefore the ratio of the average neighbourhood housing price to a household income is selected.

(b) Marketability *(NVEC).* As discussed in Chapter V, a higher level of submarket marketability enhances a buyer's expectation for the future housing price growth, therefore, increase his probability of choosing the submarket. It is also pointed out that theoretically, marketability can be measured by the submarket dwelling transaction velocity defined in Chapter IV. However, empirically, this variable is hardly to be observed. This is because it is almost impossible to observe the number of searchers in a submarket. What we can obtain is the number of dwellings traded in a submarket during a specific time.

Therefore, an approximation of the variable is used in this study. It is calculated as the percentage of the total dwelling transactions occurring in a neighbourhood housing submarket (the number of dwelling transactions in the submarket *divided by* the total number of the dwelling transactions in the whole housing market on the basis of the survey data). According to the distribution of these percentages, they are divided into three levels, 10% or below represents a low level marketability; 10% to 20% represents middle level marketability and 20% or over represents a high level marketability.

(c) Neighbourhood amenities *(NNAM).* In this study, the measurement is based on the map of 'Shopping Hierarchy of Lothian Region' provided by Lothian Region Structure Plan 1993 (See Maps Three and Four in Appendix 7-1). A superior neighbourhood amenity means that a dwelling is located near to the regional shopping area and an inferior neighbourhood amenity means that a dwelling is located near to the local shopping centre only.

(d) Physical neighbourhood condition *(NPNC)*. In the questionnaire, physical neighbourhood condition is measured by six rating scales (Appendix 6-2). However over 90% home buyers preferred to describe their physical neighbourhood using the first three ratings which are: excellent, improving and sound. Therefore, these three ratings are used to measure a physical neighbourhood quality. Empirically, it is measured by the average rate of the buyers assessment of their physical neighbourhood condition in each neighbourhood housing submarket.

(e) Neighbourhood school quality *(NSCH)*. The measurement is based on the secondary school quality of the neighbourhood. This is mainly because in the questionnaire, the dependent children are defined as children aged 16 years old or below. The survey was undertaken in 1992 and these households were the movers in 1989. So when they were choosing their dwelling, their children were 13 years old or below. As a result, secondary school quality should be an important factor influencing their neighbourhood choice. There are 40 secondary schools distributed across the region. Their qualities are evaluated by the 'percentage of 1989-90 school leavers with 5 or more Highers' (See Map Five in Appendix 7-1). Among 40 secondary schools, only three schools have 30% or more school leavers with '5 or more Highers'. The percentages of the other schools range from 3.5% to 29.65%.

(f) The distance to the work place of the head of a household *(DTW)*.There are three ways to measure *DTW*.

1. Using real distance (e.g. miles). It can provide accurate information of *distance-choice probability* cross elasticity. However, the main disadvantages are: (a) the respondents may not be able to precisely estimate the distance, especially if he/she does not drive to work. (b) real distance may become less important if there is a good transport link (Road, bus or train system). (c) the Limdep discrete choice modelling

procedure does not allow to use a variable describing household information (Appendix 7-3).

2. Using travel to work time. It remedies the disadvantage (b) above, but shares the disadvantage (c). Besides, it has an inherent disadvantage which is that different people use different transportation tools. This brings an empirical difficulty to compare the travelling time.

Therefore, the third way of measuring the influence of distance to the work place is suggested in this study. The basic rule is that regional housing market area is divided into several subareas in terms of the location of the CRA and the sub-CRAs. Assuming that a buyer's work place is located in one of the CBD or sub-CBDs. If he/she chooses the related residential area to live (e.g. the CRA or the Sub-CRA), the distance is measured by '1', which means that he/she chooses to live near to the work place. If he/she chooses the adjacent residential area to live, the distance is measured by '2', otherwise the distance is measured by '3', which means that he/she chooses to live far from the work place. Therefore the distance is measured by an ordinal variable with three levels. This rule is applied to Lothian Region and the details are given in Appendix 7-4. The advantage is that, based on this rule, we can practically calculate the choice probabilities of a mover for the residential areas as long as his/her working location is known. This result provides a link between a local labour market and the local housing market structure

(2) The alternatives are the sectoral housing submarkets.

(a) Financial constraint *(HRPI).*The reasons of choosing this variable and the definition are the same as variable 'NRPI'.

(b) Marketability *(VEC)*. The reasons of choosing this variable and the definition are the same as variable 'NVEC'. The only difference is that at sectoral housing submarket level, this percentage is calculated as the number of dwelling transaction in the submarket divided by the total number of the dwelling transactions in the nested neighbourhood.

(c) Dwelling type. *(TYPE)*. Five key dwelling related components are selected to measure dwelling type (see Table 12 in Appendix 7-2). These five components are grouped into three in terms of their similarity on the average dwelling prices: detached-or semi-detached house; terraced house and main door flat; and flat. This is because, after breaking the sample into subgroups, there are much fewer sample points in some dwelling sectors (see Table 12 in Appendix 7-2). This creates empirical calibration problems. This is a dummy variable.

(d) Dwelling size *(SIZE)* Dwelling size is measured by small dwelling (two bedrooms or less), middle sized dwelling (three or four bedrooms) and large dwelling (five or more bedrooms). This is an ordinal variable.

(e) Dwelling age *(AGE)* Dwelling age is measured by the dwelling construction date (See Table11 in Appendix 7-2). Therefore, the dwellings in the same dwelling sector were built at the similar time. This is an ordinal variable.

3. The alternatives are the individual dwellings.

Given a sectoral housing submarket nested in a neighbourhood, the dwellings are differentiated by the non-key dwelling components. These dwellings have the similar dwelling price (See Chapter III), and the financial constraint is not an important factor at this level. Therefore the stated preference technique can be used to relax the influence of the dwelling supply constraint (See the discussion in Chapter V and VI).

The survey shows that among the six non-key dwelling components (Tables 17, 21&22 in Appendix 7-2), kitchen type, central heating and private garden are more important than the other three. These three components are selected.

(a) Kitchen Type *(KIT).* Two types of kitchen are considered in the survey: a large kitchen with a dinning area and a small kitchen with a separated dinning room.

(b) Central Heating *(CH).*

(c) Private Garden *(Gard).*

They are measured by the dummy variables. The combination of the above three non-key dwelling components forms nine types of the individual dwellings (Table VII(4)).

4.<u>The effect of the household socio-economic background on the housing choice behaviour</u>

The discussions in Chapter V showed that the household family life cycle was a very important factor influencing the housing choice behaviour. Chapter VI pointed out that this effect could be investigated by comparing the model coefficients between the subgroups classified by the family life cycle.

In this study, the buyers are classified into four stages of the family life cycle and each faces 63 sectoral housing submarkets (see section 7.2). The data used are from Lothian Region Household Housing Questionnaire Survey undertaken by the author in 1992. The sample includes 710 households. Among them 125 households are single young person households, 154 households are young couple households and 329 households have dependent children; 47 households are elder single or couple households with the head(s) working and in the other 55 households, the head (s) have retired. Because of limitations of the subgroup sample size, only the subgroups of single young person households (Group1), young couple households (Group2) and the households with dependent children (Group3) are considered in this chapter.

7.4 The Choice of a Sectoral Housing Submarket

7.4.1 Introduction

A buyer's housing choice behaviour for a sectoral housing submarket can be calibrated by both the NMNL model and the MNL model (See Chapter VI). The empirical calibration work is completed by the 'Discrete choice procedure' in LIMDEP 6.0. The data structure required by the procedure is listed in Appendix 7-3. The mathematical definitions of explanatory variables are given in Appendix 7-4.

7.4.1 Comparison of the MNL Model and the NMNL Model

The discussion in Chapter VI has shown that theoretically, the application of the MNL model or the NMNL model to a housing choice problem will both bring bias to the estimation and the suitability of either model to a housing choice case is determined by the empirical results. This hypothesis is tested below.

Tables VII(5a) and (5b) present the empirical results from the NMNL model. Table VII(6) presents the empirical results from the MNL model.

Table VII(5a)

The Choice of a Sectoral Housing Submarket: Coefficients in the NMNL Model

VARs	Overall	Group-1	Group-2	Group-3
HRPI	-0.4792	-0.41678	-0.4983	-0.5673
	(0.00)	(0.09)	(0.00)	(0.00)
VEC2	1.3504	1.5011	1.3747	1.3303
	(0.00)	(0.00)	(0.00)	(0.00)
VEC3	2.2365	1.9136	2.3460	2.1245
	(0.00)	(0.00)	(0.00)	(0.00)
TYPE2	0.1882	-0.6152	-------	0.7475
	(0.155)	(0.06)		(0.00)
TYPE3	0.2274	-0.8504	-------	0.8299
	(0.15)	(0.07)		(0.00)
SIZE	0.2801	-0.7960	-------	0.7950
	(0.00)	(0.00)		(0.00)
AGE	-0.1743	-0.3191	-0.1937	-0.1482
	(0.05)	(0.22)	(0.19)	(0.25)
χ^2	577.48	221.94	145.1	263.99
Pseudo-R^2	0.56	0.84	0.62	0.56

Table VII(5b)

The Choice of a Neighbourhood Housing Submarket: Coefficients in the NMNL Model

VARs	Overall	Group-1	Group-2	Group-3
DTW	-1.1861	-1.4486	-0.9569	-1.5433
	(0.00)	(0.00)	(0.00)	(0.00)
NPNC	0.1514	-0.4577	--------	--------
	(0.07)	(0.01)	--------	--------
NNAM	-0.046	--------	-0.2779	--------
	(0.59)	--------	(0.03)	--------
NSCH	--------	--------	--------	5.18
	--------	--------	--------	(0.00)
$1-\sigma$	1.534	0.68	1.43	1.90
	(0.00)	(0.09)	(0.00)	(0.00)
χ^2	277.82	111.75	47.42	208.99
Pseudo-R^2	0.33	0.60	0.27	0.48

Table VII(6)

The Choice of a Sectoral Housing Submarket: Coefficients in the MNL Model

VARs	Overall	Group-1	Group-2	Group-3
HRPI	-0.5159	-0.7576	-0.5095	-0.6993
	(0.00)	(0.00)	(0.00)	(0.00)
VEC2	1.3654	1.6024	1.3836	1.3444
	(0.00)	(0.00)	(0.00)	(0.00)
VEC3	2.2866	2.0272	2.3678	2.2044
	(0.00)	(0.00)	(0.00)	(0.00)
TYPE2	0.1948	-0.4681	--------	0.8318
	(0.12)	(0.12)	--------	(0.00)
TYPE3	0.2488	-0.5533	-------	0.8530
	(0.09)	(0.19)	-------	(0.00)
SIZE	0.3257	-0.5702	-------	0.9656
	(0.00)	(0.01)	-------	(0.00)
AGE	-0.2343	-0.4076	-0.2638	-0.0446
	(0.00)	(0.04)	(0.03)	(0.66)
DTW	-1.3130	-1.2387	-1.0520	-1.4823
	(0.00)	(0.00)	(0.00)	(0.00)
NNAM	-0.2425	0.2551	-0.3683	--------
	(0.00)	(0.17)	(0.01)	--------
NVEC2	--------	--------	0.5662	--------
	--------	---------	(0.04)	--------
NVEC3	--------	--------	0.3835	--------
	--------	--------	(0.19)	--------
NSCH	--------	--------	--------	3.2431
	--------	--------	--------	(0.01)
χ^2	854.4	329.6	196.8	445.6
Pseudo-R^2	0.70	0.93	0.72	0.75

The column marked 'Overall' gives the empirical results based on all the sample households. In Table VII(5a), the figures represent the coefficients in equation (9) of Chapter VI, in Table VII(5b), the figures represent the coefficients in equation (10) of Chapter VI and in Table VII(6), the figures represent the coefficients in equation (1) of Chapter VI. The values in the brackets are the p-values. For example, if we use 5% as the significance level, all the coefficients, which have less than 5% p-values, will be significantly different from zero.

Because the value of χ^2 is influenced by the sample size, Pseudo-R^2, which is derived from χ^2, is used to interpret the model fit. This value is within a unit interval and a higher Pseudo-R^2 represents a better model fit.

Some variables are omitted from the models as they are not statistically significant. For example, 'NSCH' is omitted from Group 1. This is because the choice of a dwelling location for a single person household won't be influenced by the neighbourhood school quality.

An empirical comparison of the NMNL model and the MNL model is given below.

1.The comparison of the model fit.

Table VII(7)
A Comparison of the Model Fits (Pseudo-R^2)

Model	Overall	Group-1	Group-2	Group-3
NMNL-s	0.56	0.84	0.62	0.56
NMNL-n	0.33	0.60	0.27	0.48
MNL	0.70	0.93	0.72	0.75

Note: NMNL-s denotes the model fits of the choice of a sectoral submarket given a neighbourhood and NMNL-n denotes the model fits of the choice of a neighbourhood in the NMNL model. The definition of Pseudo-R^2 is given in Appendix 6-1.

Two conclusions can be drawn here: for all the sample households as well as the samples across the subgroups, the MNL model provides a much better model fit; the model fits of neighbourhood choice in the NMNL model (Table VII (5b)) are not good.

2. The significance of the coefficients. Comparing the significance of the coefficients in the MNL and the NMNL models using 5% as the significance level, it is found that,

for the 'Overall', the coefficients in the MNL model were more significant than the coefficients in the NMNL model. For the subgroups, there is no significant difference.

3. In Table VII(5b), for the 'Overall, Group2, and Group3', the coefficients of the inclusive values (1-σ) are bigger than ONE. This implies a 'potential' violation of the sufficient and necessary condition, which is that the value of (1-σ) is within unit interval, used in the NMNL model. Here, the 'potential violation' means that the true values might be bigger than one. 'Group1', the coefficient of the inclusive value is less than ONE. But this coefficient is not statistically significant at the 5% significant level. Therefore, there might also exist the 'potential' violation of the condition used in the NMNL model.

4. The explicit assumption (See Chapter VI) in the functional form of the NMNL model may cause the bias. This is supported by the evidence of the following tables

The values in Tables VII(8) ,(9a) and (9b) separately represent the restricted log-likelihood (the third column), the unrestricted log-likelihood (the fourth column), the Chi-square (the fifth column) and the Pseudo-R^2 (the last column) of the MNL model (Table VII(8)), the conditional probability of the NMNL model (the choice of a sectoral housing submarket conditional on the chosen neighbourhood, Table VII(9a)) and the marginal probability of the NMNL model (the choice of a neighbourhood housing submarket, Table VII(9b)). The definitions of the unrestricted log-likelihood, restricted log-likelihood, CHi-square and the Pseudo-R^2 were given in Appendix 6-1.

Comparing the third columns of the three tables, it is found that, the l_0, l_β, and χ^2 in Table VII(8) are about the sum of the ones in Table VII(9a) and Table VII(9b) separately. This implies that the total value of the log-likelihood is from two sources: one is from the choice of a sectoral housing submarket conditional on the chosen neighbourhood, the other is from the choice of a neighbourhood housing submarket.

Comparing the Pseudo-R^2 in the three tables, it is found that the MNL model and the conditional probability of the NMNL model provide a good model fit. However, the marginal probability of the NMNL model shows a low explanatory ability (low model fit).

There are two possible reasons: one is that the independent variables were not correctly specified to explain the neighbourhood choice. However, if this were true, the Pseudo-R^2 in the MNL model should not have been so high (See Table VII(8)). The other reason is that the implied assumption in the NMNL model is not a suitable one (See Chapter VI). In other words, we cannot simply use the inclusive value to represent the influence of sectoral housing submarket condition on a neighbourhood choice.

Table VII(8)

The Goodness of Fit of the MNL Model Over the Subsamples

MNL	N	l_0	l_β	χ^2	$Pseudo-R^2$
Overall	710	-2941.63	-2514.44	854.37	0.70
Group-1	125	-517.89	-353.06	329.66	0.93
Group-2	154	-638.04	-539.64	196.81	0.72
Group-3	329	-1363.09	-1140.29	445.6	0.75

Table VII(9a)

The Goodness of Fit of the NMNL Model Over the Subsamples (1)

NMNL-I	N	L_0	L_β	χ^2	$Pseudo-R^2$
Overall	710	-1560.03	-1271.29	577.48	0.56
Group-1	125	-274.65	-163.65	221.94	0.84
Group-2	154	-338.37	-265.82	145.1	0.62
Group-3	329	-722.89	-590.89	263.99	0.56

Table VII(9b)

The Goodness of Fit of the NMNL Model Over the Subsamples (2)

NMNL-II	N	l_0	l_β	χ^2	$Pseudo-R^2$
Overall	710	-1381.6	-1242.69	277.82	0.33
Group-1	125	-243.24	-187.37	111.75	0.60
Group-2	154	-299.67	-275.96	47.42	0.27
Group-3	329	-640.2	-535.71	208.99	0.48

The above conclusions provide show that, on the basis of the statistical diagnostics available, the MNL model is superior to the NMNL model for this housing choice case. This is contrary to the previous arguments (McFadden 1978, Quigley 1985), which emphasised that the NMNL model is theoretically superior to the MNL model in a housing choice circumstance. In fact, the previous research over emphasised the violation of the IIA axiom implied by the MNL model and lacked of considering the empirical estimation biases caused by using the NMNL model.

One point has to be stressed that the conclusion above does not mean that the MNL model is better than the NMNL model in all cases of housing choice. In this case the MNL model gives a better result, which only means that the estimation biases from the NMNL model are larger than those from the MNL model. In addition, the MNL model is a simultaneous housing choice model and the NMNL model is a sequential housing choice model. Although the conceptual framework in Chapter V shows a hierarchical choice set structure and a buyer's decision making process can be a simultaneous process or a sequential process, the MNL model provides a better fit. This implies that the sequence used in the discrete choice model is conceptually different from the sequence used in describing the housing choice decision making process. This result clears the ambiguous assumption implied in some previous housing choice literature (e.g. Boehm 1982, Quigley 1985), which is the two sequences are assumed to be the same.

The implication of the results in this study is that there does not exist a model which is definitely superior to another. The choice of a suitable model mainly depends on the empirical results or data. This is consistent with the theoretical argument in Chapter VI.

7.4.3 Empirical Results: choosing a housing submarket

The results (See Table VII(6)) show that the MNL model provides a good model fit for all the sub-sample groups. By systematically adding or omitting a variable to and from the models, the coefficients in the table were found to be robust. The hypotheses discussed in Chapter V are tested by the conclusions in this section.

The hypothesis (Chapter V) that the household housing preferences have a clear life-cycle pattern is proved by the coefficients in Table VII(6). As King (1980) has pointed out, it appears important to allow the housing preferences to be distributed across the population. Table VII (6) shows that young single person households prefer to buy smaller flats located in the central area of Edinburgh, which has a good neighbourhood amenities. Households with dependent children prefer to buy larger houses from a neighbourhood with good quality schools. For this group, the coefficients of the dwelling age are not significant, showing that the dwelling age has less influence on their housing choice. The coefficients of the dwelling type and size of young couple households are very insignificant and are dropped from the model. Looking at the survey data, their dwelling interests are seen to be very much more varied than those of the other groups. One possible reason is that the incomes of this group are generally high and the family size is small, giving them a larger range of dwellings to select from. Their choice may also be influenced by their future family plans, unknown to this survey. Because their preferences vary a lot, the coefficients become very insignificant. However, this group of households has shown their strong preference of locating in a neighbourhood further from city centre (See the negative coefficient of 'NNAM' in the table).

This life cycle pattern implies that there is a distribution of the price elasticities of demand across the consumers, which is both interesting in itself and significant for an analysis of the housing wealth gain and loss from submarket housing price changes. For example, if the house price in a sectoral housing submarket of small flat changes, the influence on single young person households will be stronger than on any other groups as this type of dwelling are more preferred by them.

The influence of the distance to the work place on the housing choice behaviour is well documented (see the discussion in Chapter V). Quigley (1985) provides USA empirical evidence which is the households are willing to bid a substantial premium for a more accessible location to their work place. He finds that, to save one hour commuting time by car per month, households are willing to pay $2.29 per month in higher rent, or about 62% of the average pre tax hourly wage.

In this study, the finding is, if other things are equal, the logit of a buyer choosing a dwelling from the same location as his work place is 1.31 compared with choosing a dwelling from the adjacent location (see Appendix 7-4). For example, in Lothian Region, if a person gets a job in West Lothian, the logit of he/she choosing a dwelling from the West Lothian housing market is 1.31 compared with choosing a dwelling from the adjacent locations, e.g. from the Edinburgh housing market or the Linlithgow housing market. This result is very useful in investigating the influence of a local labour market change on the local owner occupier housing market.

The evidence in this study also shows that their preference has a clear life cycle pattern. This is contrary to the argument of Blackley & Ondrich (1988), which is that controlling for unit quality and size, the socio-economic characteristics are not significantly related to the distance from the central business district (CBD). Their findings are based on the USA rental housing market.

In Lothian Region owner occupier housing market, it appears that households with dependent children have the strongest propensity to live near to the work place of the head of a household, their preference for 'short distance to the work place' is almost 41% (the calculation is based on the difference between the coefficients) higher than young couple households. This is because, most young couple households have two working people (e.g. husband and wife). They prefer to choose a place which is convenient for both of their work places, but not just for one of them.

The big gap between the housing price and the income constrains a buyer's choice of a dwelling (See Chapter V). It has been proved in previous studies (Kain & Quigley 1975, Ellickson 1981, Boeham 1982, Follain & Jimenez 1985) that higher income households prefer higher quality dwelling. Follain & Jimenez (1985) also indicates that the income elasticity of the demand for living space is less than the income elasticity of the demand for amenities (Canadian Rental Housing Market). Although these research provides affluent evidence of the role of income on housing choice, few of them has investigated the effect of the ratio of the housing price to the income on a housing choice in an owner occupier housing market. This ratio is crucial as it reflects the trade-off between the housing consumption and the non-housing consumption in the current mortgage system (See the discussion in Chapter V). In this studies, this effect is analysed.

The empirical evidence shows that all the buyers prefer to choose a lower ratio, and this preference has a life cycle pattern. Single young person households and households with dependent children prefer to choose a lower ratio compared with young couple households. Their preferences for choosing lower ratio are 48.7%, 37.3% higher than young couple households. This is not surprising: single young person households generally have a lower income and face a stronger budget constraint, and they may also prefer to spend more money on holidays or other leisure activities. Households with dependent children may have higher non-housing expenditures due to their children. As a result, although they generally have higher incomes, they prefer to choose a lower ratio. These conclusions testify the hypothesis in Chapter V and show the important role of the ratio on housing choice behaviour.

The most significant contribution of this housing choice model is the development of the identification of the choice hierarchy. Being different from the previous research (Boehm 1982, Quigley 1985, Birsch-Supan 1986), this study identifies a hierarchical housing choice set based on a nested housing submarket structure defined and discussed in Chapter III. This identification allows us to investigate how housing submarket marketability (measured by the dwelling transaction velocity defined in Chapter IV) influence housing choice behaviour. Chapter V has argued that a higher dwelling transaction velocity in a submarket enhances a buyer's expectation for the future house price growth, therefore, increases their choice probability for the submarket. The empirical results (The coefficients of 'VEC') in this section show that, on average, higher marketability will attract more housing buyers to the submarket. Particularly, the logit of a buyer choosing a dwelling from a submarket with middle level marketability rather than from a submarket with lowest level marketability is 0.19, but the logit will be 0.05 if a buyer choosing a dwelling from a submarket with highest level marketability rather than from a submarket with middle level marketability. This is because, higher level marketability implies the submarket housing price is high and this may constrain a buyer's preference for that submarket.

The results from the subsamples show that this preference does not have a clear life-cycle pattern. But the coefficient in the model show that younger households are more likely to choose a dwelling from a sectoral housing submarket with higher marketability. This implies that the younger home owners emphasis the role of buying a dwelling as a family investment more than the older home owners do. This implication is consistent with the result of Tu & Maclennan (1995).

The influence of submarket marketability at neighbourhood level is not significant except for subgroup-2. This is because there exists collinear between the sectoral level marketability and the neighbourhood level marketability. Although there is an exception for subgroup-2, the indicator variable (NVEC3) is not significant at 5% level.

The above empirical results have testified the theoretical conclusions in Chapter V. However, the discussion so far has been focusing on submarket level. Given a sectoral housing submarket nested in a neighbourhood, the choice for an individual dwelling is also important. As the dwellings are differentiated by their non-key dwelling components within a sectoral housing submarket, an attractive combination of the non-key dwelling components related to a dwelling in the submarket can draw more housing buyers towards the submarket. This will be discussed in the next section.

7.5 The Choice of a Dwelling from a Sectoral Housing Submarket

In this section the MNL model is chosen to empirically calibrate the revealed and the stated non-key housing preferences. Limdep 6.0 is used to undertake the calculation. The mathematical specification of the independent variables is given in Appendix 7-4. The discussion in this section will provide empirical evidence of how the dwelling supply constraint can be relaxed using the stated preference data.

Table VII(10) presents the empirical results of the household housing preference for the non-key dwelling components. The calibration work was initially undertaken by adding an income variable to the model. However, the coefficient is not significant. After omitting the income variable, the value of χ^2 shows no significant change and the coefficients of Kitchen, Central Heating and Garden are relatively robust. This proves the hypothesis (See Chapter III) that the budget constraint does not significantly influence the choice of the non-key dwelling components.

Table VII(10)

The Choice of a Dwelling Given a Sectoral Housing Submarket: Coefficients in the MNL model.

VARs	Overall		Group-1		Group-2		Group-3	
	RP	SP	RP	SP	RP	SP	RP	SP
Kitchen	-0.0810 (0.30)	1.1370 (0.00)	-0.6549 (0.00)	1.7720 (0.00)	-0.1266 (0.46)	1.2010 (0.00)	0.0998 (0.39)	1.0505 (0.00)
Central Heating	1.7352 (0.00)	1.8452 (0.00)	0.6932 (0.00)	1.7050 (0.00	1.7373 (0.00)	1.9694 (0.00)	2.1644 (0.00)	1.8192 (0.00)
Garden	1.0649 (0.00)	0.6954 (0.00)	-0.4340 (0.02)	0.12 (0.52)	0.7239 (0.00)	0.8505 (0.00)	2.1290 (0.00)	1.0161 (0.00)
χ^2	527.34	654.28	30.54	127.4	98.3	163.62	431.75	315.54
Pseudo-R^2	0.81	0.87	0.41	0.90	0.75	0.90	0.96	0.89

The results in the table show that the MNL model fits the stated preference data much better than it fits the revealed preference data. All the coefficients in the stated preference models are significant except the coefficient of 'Garden' in Group-1. Some coefficients in the revealed preference models are not statistically significant. They are the coefficients of 'kitchen' type across the subgroups except Group-1. The results also show that these coefficients are negative in the RP model.

These two results together with the positive and significant coefficients in the SP models show the influence of the housing supply constraint on housing choice. This is discussed below.

1. The stated coefficients of 'Kitchen' across the life cycle show that people prefer to buy a dwelling with large kitchen, e.g. the kitchen with a dinning area. However, the revealed coefficients give the different results. As it has been discussed at the beginning of this section, income constraint does not significantly influence a buyer's choice for the non-key dwelling components. Therefore, this difference implies the effect of supply constraint on housing choice. In other words, people prefer to have a large kitchen inside the dwelling. Because of the supply constraint, this type of dwelling is not always available. Their revealed choice is not their maximum utility choice. This results in the inferior model fits in RP models. Overall, the SP model shows that the logit of a buyer choosing a dwelling with a large kitchen in contrast to a dwelling with small kitchen is 1.14. This propensity becomes stronger for single young person households, the logit is 1.77.

2. Both the stated and revealed coefficients of 'Central Heating' across the life-cycle show that people prefer to have central heating. Their stated preference is generally stronger than their revealed preference. Overall, in the SP model, the logit of choosing a dwelling with central heating in contrast to a dwelling without central heating is 1.84. The difference between the SP preference and the revealed preference is very strong for single young person households. The logit value increases from 0.69 to 1.71. This is because single young person households prefer to buy small flat located in the central Edinburgh area. These flats are generally very old without central heating system. The physical dwelling stock adds the dwelling supply constraint on a buyer's choice. When SP technique is used, such constraint is relaxed. In other words, SP information provides more precise data to reflect a buyer's housing preference when income constraint is less important.

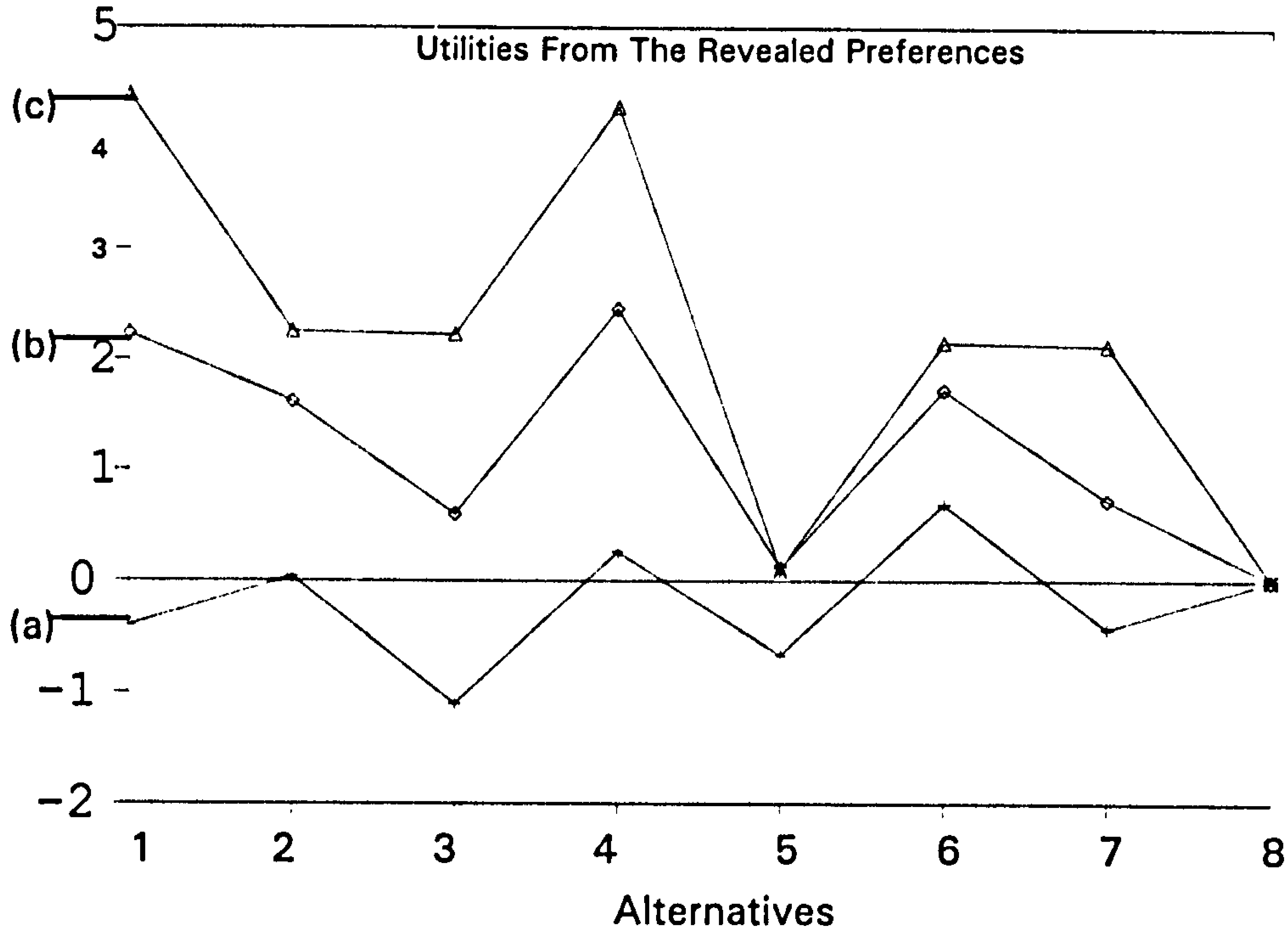
3. Both the stated and revealed coefficients of 'Garden' across the life-cycle show that people prefer to have their private gardens except single young households, where the stated preference coefficient is insignificant and the revealed preference coefficient

shows this is not often available in the types of dwelling chosen by this group. However, the preference for private garden becomes stronger among the households with dependent children.

The difference between SP and RP can be further compared by Diagrams VII(12) & (13) below. In the diagrams, two groups of utility curves (SP and RP) are presented to show how a household's non-key dwelling component preferences change across the life cycle as well as across the different combinations of the non-key dwelling components.

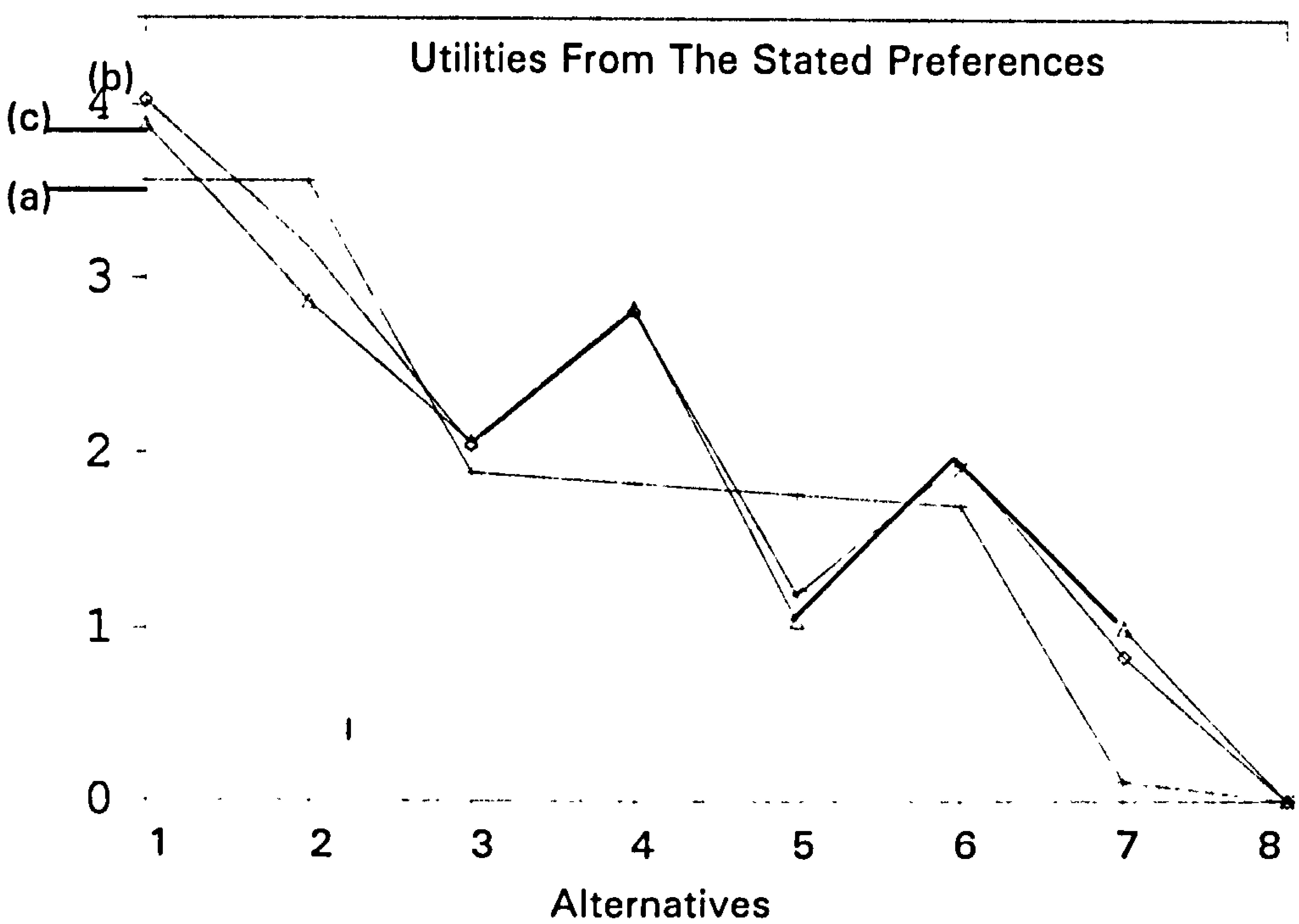
In the diagrams, the X-axis represents the 8 different types of dwellings differentiated by the three non-key dwelling components. The definition is given by Table VII(4). The Y-axis is the utility a buyer can obtain from choosing a dwelling given a sectoral housing submarket. The utility is calculated by replacing the values in Table VII(4) into Table VII(10). The calculation is based on the subgroups. In the diagrams, Line (a) denotes Group-1 households; Line (b) denotes Group-2 households and Line (c) denotes Group-3 households.

Diagram VII (3)



Note: (a) = Group-1, (b) = Group-2, (c) = Group-3.

Diagram VII(4)



Notes: (a) = Group-1, (b) = Group-2, (c) = Group-3

Comparing the two diagrams, a number of conclusions can be drawn.

1. Under the dwelling supply constraint (Diagram VII(3)), households with dependent children (Line (c)) show a much stronger preference for the dwellings with any of the three components than the other two groups of households, except for the alternatives 5 and 8 which are the dwellings without central heating and private garden. This is related to the dwelling types practically chosen by this group of people (See Section 7.4.3). If the supply constraint is relaxed (Diagram VII (4)), the differences between the subgroups are reduced dramatically. Households with dependent children and young couple households show almost similar housing preferences.

2. Both diagrams show that if a dwelling has large kitchen, central heating and private garden, it will have the highest probability to be chosen by all kinds of households. The stated preference result also shows that a household's preference for a dwelling varies as the combinations of the non-key dwelling components within a dwelling changes. Basically, his/her preference declines as the number of the non-key dwelling components within a dwelling are reduced. Particularly, a dwelling with large kitchen or central heating is more popular. This implies that kitchen type and central heating system within a dwelling are very important non-key dwelling components influencing housing choice behaviour.

The conclusions are: 1. changing the combinations of the non-key dwelling components inside a dwelling influence a buyer's preference for a dwelling, therefore, will influence the marketability of the related housing submarket; 2. when the income constraint is less important, the dwelling supply constraint limiting a buyer's choice can be relaxed by using the SP technique.

This chapter provides empirical evidence to support the theoretical conclusions in Chapters V and VI. The main conclusions are that: 1. the MNL model can provide the superior empirical results than the NMNL model, at least for this case; 2. the hierarchy dwelling choice set on the basis of a nested housing submarket structure can provide greater insight into the effects of housing submarket properties on housing choice behaviour; 3. a combination of the RP and SP techniques can provide more precise information to reflect the household housing preference.

In the next chapter, a broad conclusion about the whole research will be drawn. The future research potential to be developed from this research will be discussed.

CHAPTER VIII CONCLUSIONS

8.1 Contributions to the Housing Market Literature

This study has a number of contributions to the micro housing market literature reviewed in Chapter II. It is worth summarising the main points below.

Theoretically, this study, for the first time, explicitly defines a local housing submarket structure as a nested structure. The definition includes both the submarkets at neighbourhood level and the submarkets at sector level. This is an improvement to the previous housing submarket research where housing submarket structure was regarded at neighbourhood level only. With the consideration of housing submarket trade friction, the dynamic stock flow approach is revised and applied to this structure. The discussion explores both the long run and short run housing submarket equilibrium and disequilibrium properties which have received little attention previously. The model remedies the main drawback of neo-classical micro housing economic theory which assumes frictionless trade in a housing market.

Empirically, three suggestions concerning modelling housing choice behaviour can be made. 1. It is necessary to draw a distinction between the sequence used in a statistical discrete choice model and the sequence used in describing the housing choice decision making process. This difference was ignored and the two concepts were misused in the previous housing choice models. 2. The selection of a statistical discrete choice model should consider the empirical model fit, rather than only consider the inherent drawbacks of a statistical model as the previous housing choice models did. 3. A three level hierarchical choice set based on a nested housing submarket structure provides a deeper insight in understanding the household housing choice behaviour.

This study, for the first time, suggests that the combination of the stated preference information and the revealed preference information can provide a deeper insight into household housing choice behaviour. The empirical model emphasises the influence of the nuclei regional labour market structure (e.g. CBD is the main employment centre around which there are a number of sub-employment centres) on housing choice behaviour. Therefore, at regional level, the distance to the work place rather than the distance to the CBD as assumed in most of the previous housing choice models is one of the key factors influencing housing choice. Another empirical contribution is that housing submarket trade friction is proved to be an important variable in explaining housing choice in a housing submarket.

8.2 Summary of Findings

The thesis adopted a revised dynamic stock-flow model with trade friction to analyse a nested housing submarket system and empirically estimated a household housing choice model in a regional owner occupier housing market. These aspects have been selected as mutually interdependent, but relatively neglected areas of the existing housing market literature.

A more detailed discussion about this research topic selection is given in Chapter I. The identification of a local housing submarket structure and the investigation of its short term and long term equilibrium as well as disequilibrium properties are very important in micro housing economics. It was seen in Chapters I&III that the unavoidable housing search behaviour has caused an important housing submarket phenomenon, namely, housing submarket trade friction. Therefore, the conventional neo-classical economic theory does not apply to housing market. Understanding and analysing the operational process of a local housing submarket with trade friction is deemed therefore necessary. The results provide a theoretical foundation for housing market modelling at both urban and regional levels. One of the applications is to model the household housing choice behaviour per housing submarket at regional level.

Chapter II concludes that the conventional micro housing economic theory has several critical drawbacks and cannot be applied to a local housing market. Therefore, a new approach, namely a dynamic stock-flow model with trade friction initially developed by Weibull (1983) is introduced. This approach provides a general framework to explore regional or urban housing submarket operation in the context of a housing submarket and submarket trade friction. However, this latter application has been ignored by previous research.

This Chapter critically examined a variety of housing econometric models which progressively reduce the level (in terms of spatial dimension) of analytical abstraction and introduced notions of dwelling heterogeneity. The models are classified into three groups. It was shown that the dynamic evolution of house prices, demands and supplies is the central premise of macro housing econometric models. Although the dynamic behaviour of a housing market is a crucial issue, it only reflects partial information in the housing market because of the ignorance of spatial and dwelling type disaggregation. Particularly in an owner occupier housing market, these are important factors influencing housing choice behaviour. The models at regional level have focused on regional owner occupier housing market interaction. The geographic models and the cointegration models provide a deeper insight to such interdependence. However, these models are not perfectly defined without considering the role of dwelling type variety. Urban housing models, which are mainly derived from the utility maximisation approach attempt to consider two notions, namely space and dwelling type. In these models, the role of space is reflected by the distance to the CBD. This assumption is clearly unsuitable in a regional context. At regional level, there exists not only a hierarchy of shopping centres, but also a hierarchy of employment centres. This regional spatial speciality together with the existence of housing submarkets requires the development of a regional housing choice model.

The definitions clarified in Chapter III show that a nested housing submarket structure is a suitable structure to describe the link between the local housing submarkets. Based on the approach of the Minimum Household Unit (Ermisch & Overton 1985), the households are grouped into four stages of the family life cycle. The household housing search process in the context of a nested housing submarket structure was examined. This reveals the essence of housing submarket trade friction, which is, during any time period, the number of dwelling transacted is only a fraction of the short side of the housing demands and supplies (See Eq. 1 in Chapter III).

In Chapter IV, a revised dynamic stock-flow model with trade friction was applied to a nested local housing submarket structure. The model is developed on the premise that within one time unit, at each housing submarket, the number of dwellings traded is a fixed percentage of the short side of the submarket housing demands and supplies (Eq. 20) in Chapter IV. A detailed discussion about the operational process of a local housing submarket system was given in Chapter IV, and its salient features are presented below. As in the short run, new dwelling supply is a very small fraction of the total housing stock, the discussion in this thesis is under the assumption that a local housing market is demand oriented.

1. A nested local owner occupier housing submarket system has one and only one dynamic stock flow equilibrium position in the short run. This equilibrium has three aspects: first, in each sectoral or neighbourhood housing submarket, there is no price movement and housing demand is equal to housing supply; second, in each sectoral or neighbourhood housing submarket, the extra housing demand, supply and the number of dwellings traded within each time unit are all equal; finally, all the housing submarkets can achieve their equilibrium position at the same time.

2. The short run submarket equilibrium housing price is determined by the household housing preference for the submarket and the submarket condition. The latter includes: the dwelling and the neighbourhood components, the dwelling stock, the vacancy rate, the dwelling re-choice rate (during the search), and the submarket dwelling transaction velocity (defined as the inverse of the submarket trade friction). The submarket equilibrium price will change given any change of the above factors.

3. The implications in the long run are that, in each housing submarket, there exists a long run equilibrium *path* along which the submarket housing prices change. The shape of this path is determined by the changes in the above factors. For example, if other things are unchanged, but the physical neighbourhood appearance has been improved over time, the submarket equilibrium housing price will be increased over time. For this submarket its long rum equilibrium path will be subject to an upward trend. The bigger the change is, the sharper the trend will be. This implies that, the dynamics of the house prices in the different housing submarkets have two possible long term relationships: first, they may move closely together, even though the series themselves are trended, the difference between them is constant. In other words, the submarket house prices are either increasing or decreasing at the same rate over time; second, they may drift increasingly further away from each other or come together as time goes on. This may happen if some housing submarkets become deteriorating, while others become prosperous.

4. The short run housing submarket equilibrium properties are therefore: (if other things remain unchanged)

a. the equilibrium submarket housing demand and supply is a strictly increasing function of the submarket dwelling stock and the vacancy rate;
b. the equilibrium submarket housing demand and supply is a strictly

increasing function of the submarket trade friction;

c. the equilibrium submarket house price is negatively related to the submarket trade friction, but positively related to the qualities of the dwelling related and the neighbourhood related components. It is also negatively related to the household housing preference for the other housing markets, e.g. the owner occupier housing markets in the adjacent urban area or region, or the private rental housing market and social housing. The above relationship is represented by the following equation: (The definition of each variable is given in Appendix 4-2)

$$p_{ij} = f(-TF_{ij}, +X_{ij}, +Y_i, +\Pr_{ij} - \Pr_o)$$

5. The computer simulation demonstrates that this short run dynamic stock flow equilibrium can be in one of three states: Neighbourhood Stable, Bounded Instable, and Instable, which depends on the segmentation of the housing submarket structure. It has been argued that, in reality, the housing submarket equilibrium is more likely to be in the state of Bounded Instability. This result together with the discussion above implies that, as time goes on, the submarket housing price moves along its long term equilibrium path with short term dynamics. The household housing choice probabilities for the housing submarkets are the key in directing the changes in the housing submarket demands and supplies.

After examining the importance of household housing choice behaviour in directing a local housing submarket operation in Chapter IV, Chapter V presented a theoretical regional housing choice model per housing submarket based on the random utility approach. From this model, the factors influencing the household housing choice behaviour were drawn. Four major conclusions are made:

1. Household housing choice behaviour has a family life cycle pattern, in terms of the dwelling type, size and the neighbourhood conditions.

2. Housing submarket trade friction decreases the submarket marketability. Therefore it is negatively related to the household housing preference for the submarket.

3. The distance to the work place rather than the distance to the CBD is an important factor in determining the household housing choice for a residential location in a regional owner occupier housing market.

4. Housing choice is strongly constrained by the buyers' housing financial affordability. This confines each buyer to the submarkets which he/she can afford.

After examining the institutional and economic background of the household housing choice behaviour in Chapter V, Chapter VI gives a detailed discussion of the statistical model selection and the empirical data collection techniques in the context of housing choice. The discussion proves that:

1. The sequential concept used in a sequential statistical model is different from the sequence used in describing household housing choice decision making process.

2. Each type of statistical discrete choice model has its merits and limitations. The selection of the model mainly depends on the empirical model fit. The discussion in Chapter VI suggests that the NMNL model and the MNL model should be selected. This is mainly because the coefficients in these two models have a direct economic implication. However, which model is suitable for modelling household housing choice behaviour per submarket will depends on the empirical comparison. This model selection rule was ignored by the previous housing choice studies.

3. The existing housing choice models are either based on the revealed housing preference or based on the stated preference information. After examining the suitability of two information collection techniques, namely, the stated preference (SP) method and the revealed preference (RP) method, to a housing choice case, it is suggested that the RP method should be used to collect the information of a buyer's choice for a housing submarket and the SP information is a better way to reflect a buyer's preference for a dwelling after choosing a sectoral housing submarket.

Chapter VII gives estimation for the models suggested in Chapter VI and the data is from the questionnaire survey discussed in the same chapter. The explanatory variable selection is based on the theoretical model in Chapter V. The estimation testifies the hypotheses raised in Chapters V&VI. The following main conclusions are indicated.

1. The empirical comparison shows that, for this data set, the MNL model is superior to the NMNL model. This conclusion raises a mistrust of the hypothesis used in the previous hierarchical housing choice models. This hypothesis is the counterpart to the conclusion in this study and was stressed because of the unavoidable violation of the IIA axiom inherited by the MNL model in the housing choice case. Therefore, it is confirmed here that the statistical model selection should depend on the empirical model fit.

2. The family life cycle pattern of the household housing preference is that: young single person households prefer a small flat located near to the CBD. They regard that the central heating and a large kitchen are very important *non-key* dwelling components within the flat; households with dependent children prefer a large house located near to a good quality school. Having a private garden is also conceived as an important factor influencing their housing choice; and young couple households do not show a clear preference for the dwelling type and size, but prefer to live near to

the CBD. Central heating is given as the most important *non-key* dwelling component by all types of households.

3. The empirical results have shown that the household housing financial constraint significantly influences the choice for a housing submarket. After a sectoral housing submarket is chosen, the financial constraint is released at the stage of choosing a dwelling from the submarket. Therefore, the supply constraint becomes important. However, the application of the SP technique liberates the supply constraint. The result is that the RP method together with the SP method can provide a better insight into the household housing choice behaviour.

4. If other things remain unchanged, in a regional owner occupier housing market, the households prefer to live near to the employment centre or sub-centre. It depends on the work place of the head of the household. For example, in Lothian Region, Edinburgh is the employment centre. East, West and Mid Lothian, each has its own employment sub-centre. The empirical results show that, on average, if a person works in Edinburgh, the probability of choosing a dwelling from Edinburgh is 3.7 times as much as the probability of choosing a dwelling on the outside of Edinburgh area (Other things remain unchanged); if he/she works in East Lothian, the probability of choosing a dwelling in Edinburgh is 1/4 of the probability of choosing a dwelling in East Lothian, and the probability of living in West or Mid Lothian will be 1/13 in contrast to living in East Lothian. It is corroborated that the buyers' residential location choice is shaped by the distribution of regional employment.

5. Housing submarket marketability (which is negatively related to the submarket trade friction) is empirically proved to be an important factor influencing the household housing choice for a submarket. If other things remain unchanged, all types of households prefer to choose a submarket with a high marketability, especially, younger households. Higher marketability implies a higher increasing rate of the

future submarket housing price. This intimates the dual role of buying a dwelling: as a family asset investment and as a shelter.

The major conclusions of this work have been discussed above. The next section discusses possible model extensions and the policy implications.

8.3 Model Extensions and Policy Implications

Both the theoretical model (Chapter IV) and the empirical model (Chapter V to VII) are constructed for a local (the former) and regional (the latter) owner occupier housing market. They can be extended to analyse the rental housing market.

For example, in a rental housing market where there exists both private rental (pure market) housing submarket and publicly regulated (rent control) housing submarket, the dynamic stock flow model can be adapted by using rent to replace house price. Therefore, the model can be used to simulate the effect of public house rent control by releasing the assumption of a 'Pure Housing Market'.

The empirical housing choice model can also be conformed to estimate housing choice in a private rental housing market. However it should be noted that, in a private rental housing market, renting a dwelling is for consumption only. Therefore, the submarket marketability, which is a substantial factor influencing housing choice behaviour, becomes insignificant. The omission of this variable in a rental model may augment the influence of the other factors, for example, rent.

The following discussion will focus on the policy implications derived from this work.

1. One of the conclusions in Chapter IV is that a local owner occupier housing submarket structure evolves as time goes on. Some housing submarkets may decay and others may prosper as a result of the neighbourhood, the dwelling quality and the household housing preference changes. This raises an important policy question: what are the reasons behind these changes?

The answer to this question is important as, in the UK, the owner occupier housing market has become the dominant tenure. Changes in the owner occupier housing submarket structure has a direct link with the changes in the local social, political and economic system. The intensity of neighbourhood deprivation has led to concerns that the poorer parts of an urban area may create a drag on economic recovery (Kintrea 1994). An empirical phenomenon is that: most British cities have faced changes in their economic base, and within a city, similar neighbourhoods at the onset of change have deteriorated whilst others remain stable or become prosperous. Therefore understanding local owner occupier housing submarket change and revealing the reasons behind are the key to understanding urban decline and attempts at regeneration. The nested housing submarket structure defined in Chapter III and the nature of the structure discussed in Chapter IV provide a theoretical foundation for analysing local owner occupier housing submarket structure evolution.

2. From the viewpoint of city planning, an investment in the owner occupier housing market may result in housing submarket structure change. The conclusions in Chapter IV show that the intensity of submarket structure segmentation determines the housing submarket system stability, and even for a highly segmented housing submarket system, only the neighbourhood scale change can keep the housing submarket system stable. Therefore, the investment policy should consider the possible investment effects. For example, the aim of the policy should be to increase local housing submarket structure segmentation and avoid a large scale change in housing submarket structure in the short run.

Finally, the investment should also consider the household housing preference and the regional employment distribution. The empirical results in Chapter VII have shown the clear life cycle pattern of the household housing choice behaviour and the strong preference for the short distance to the work place. The analysis in this thesis is based on cross sectional data, therefore the dynamics of the household housing choice behaviour is unclear. It is suggested that a regular (e.g. every 3 or 5 years) analysis of household housing choice behaviour based on the model discussed in Chapters V to VII is necessary. This can provide the essential dynamic information for city planning.

This thesis has attempted to provide a better understanding of the local owner occupier housing system. The dynamic stock flow approach has been adopted to describe the operational process of a local housing system, and the MNL discrete choice model has been used to forecast household housing choice behaviour at regional or large urban level. This approach to the dynamic nature of the housing market has provided deeper insights to how housing markets change over time than was previously possible.

Appendices

Appendix 4-1
The Derivation of The Equilibrium Point

The proof is based on the equilibrium conditions presented by equations (30) to (35) in Chapter IV. In the following equations, 't' is dropped as the market is in equilibrium.

Proof:

Step 1: substitute Equations (20) and (21) into Equation (30).

As $d_{ij}=s_{ij}$:

$$\beta_{ij} * s_{ij} = \varepsilon_{ij} * (\delta_{ij} - s_{ij})$$

$$d_{ij} = s_{ij} = \frac{\varepsilon_{ij} * \delta_{ij}}{\beta_{ij} + \varepsilon_{ij}} \qquad \text{(a)}$$

Step 2: as $d_{ij}=s_{ij}$, Equation (7-1) in Chapter IV can be re-written as:

$$q_{ij} = \frac{s_{ij}}{\beta_{ij} * \min(d_{ij}, s_{ij})} = \frac{1}{\beta_{ij}} = TF_{ij} \qquad \text{(b)}$$

Step 3: substitute equations (19) and (21) into equations (25-1) to (25-3):

$$a_i = \sum_j a_{ij}$$

$$c_i = \sum_j c_{ij}$$

So:

$$a_i = (D + \sum_{k\lambda} \gamma_{k\lambda}^2 * d_{k\lambda}) \Pr_i - \sum_j \gamma_{ij}^2 * d_{ij}$$

$$c_i = \sum_j \varepsilon_{ij} * (\delta_{ij} - s_{ij})$$

As $a_i=c_i$,

$$\Pr_i = \frac{\sum_j \gamma_{ij}^2 * d_{ij} + \sum_j \varepsilon_{ij} * (\delta_{ij} - s_{ij})}{D + \sum_{k,l} \gamma_{kl}^2 * d_{kl}} \qquad \text{(c)}$$

from equations (4) and (5) in Chapter IV:

$$\Pr_0 = 1 - \sum_i \Pr_i = \frac{D - \sum_{i,j} \varepsilon_{ij}(\delta_{ij} - s_{ij})}{D + \sum_{i,j} \gamma_{ij}^2 * d_{ij}} \qquad \text{(d)}$$

Equation (4) holds if the market satisfies the condition $D \geq \sum_{i,j} \varepsilon_{ij} * (\delta_{ij} - s_{ij})$

Step 4: substitute equations (19) and (21) to $a_{ij}=c_{ij}$.

$$((D + \sum_{i,j} \gamma_{ij}^2 * d_{ij}) * \Pr_i + \sum_j \gamma_{ij}^1 * d_{ij}) * \Pr_{j/i} - (\gamma_{ij}^1 + \gamma_{ij}^2) * d_{ij} = \varepsilon_{ij} * (\delta_{ij} - s_{ij})$$

substitute equation (c) in the appendix to the above equation:

$$\Pr_{j/i} = \frac{\varepsilon_{ij} * (\delta_{ij} - s_{ij}) + (\gamma_{ij}^1 + \gamma_{ij}^2) * d_{ij}}{\sum_j (\varepsilon_{ij} * (\delta_{ij} - s_{ij}) + (\gamma_{ij}^1 + \gamma_{ij}^2) * d_{ij})} = \Pr_{j/i}^* \qquad \text{(e)}$$

Step 5: comparing equations (4), (5) in Chapter IV and (c), (d) in the appendix

$$\frac{\Pr_i}{\Pr_0} = \exp(\lambda * Y_i + (1-\sigma) * I_i) = \frac{\sum_j \gamma_{ij}^2 * d_{ij} + \sum_j \varepsilon_{ij} * (\delta_{ij} - s_{ij})}{D - \sum_{i,j} \varepsilon_{ij} * (\delta_{ij} - s_{ij})} = \frac{\Pr_i^*}{\Pr_0^*}$$

So: $$I_i = \frac{\ln(\frac{\Pr_i^*}{\Pr_0^*})}{1-\sigma} - (\lambda/(1-\sigma)) Y_i \qquad \text{(f)}$$

From equations (3) and (6) in Chapter IV and (e) in the appendix:

$$\exp(\alpha_1 * p_{ij} + \alpha_2 * q_{ij} + \alpha_3 * X_{ij}) = \exp(I_i) * \Pr_{j/i}^*$$

Taking logs and substituting equation (f) in the appendix to the above equation:

$$p_{ij} = -\frac{\alpha_2}{\alpha_1} * q_{ij} - \frac{\alpha_3}{\alpha_1} * X_{ij} - \frac{\lambda}{\alpha_1 * (1-\sigma)} Y_i + \frac{1}{\alpha_1} * \ln(\Pr_{j/i}^*) + \frac{1}{\alpha_1 * (1-\sigma)} * \ln(\frac{\Pr_i^*}{\Pr_0^*}) \qquad \text{(g)}$$

End of Proof.

Appendix 4-2

The Definitions of the Parameters for Chapter IV

Subscripts:

i=neighbourhood housing submarket.

j=sectoral housing submarket.

Parameters:

TF=submarket trade friction. The definition is given in chapter III.

β=submarket dwelling transaction velocity, defined as an inverse of TF.

$Pr_{j/i}$=the conditional probability of an individual choosing the j^{th} sectoral housing submarket conditional on choosing the i^{th} neighbourhood housing submarket.

Pr_i=the marginal probability of an individual choosing the i^{th} neighbourhood.

Pr_{ij}=the probability of choosing the ij^{th} sectoral housing submarket, which is the product of $Pr_{j/i}$ and Pr_i.

q=the sellers' waiting time in a submarket.

d=the current effective housing demand in a submarket.

s=the current effective housing supply in a submarket.

p=the current house price in a submarket.

D=the extra housing demand to the whole housing market.

a=the extra housing demand to a submarket within a unit time.

c=the extra housing supply to a submarket within a uint time.

b=the number of dwellings transacted in a submarket witnin a unit time.

X=the components of a sectoral housing submarket.

Y=the components of a neighbourhood housing submarket.

$\alpha_1,\alpha_2,\alpha_3,\lambda$=the coefficients of p, q, X, Y in the nested logit model (NMNL model).

δ=the total housing stock in a submarket.

ε=the dwelling vacancy rate in a submarket.

$(1-\sigma)$=the coefficient of the inclusive value in the NMNL model.

$\gamma^{1,2}$=the housing buyers' re-choice rates with respect to re-dwelling choice and re-neighbourhood choice in a sectoral housing submarket.

Note: for each parameter, if any subscripts are attached, it will denote the corresponding value in that housing submarket.

Appendix 4-3

A Summary of The Simulation Background

This appendix summarises the simulation background. The diagram gives the housing submarket structure used in the simulation. The parameter (Appendix 4-2) values used in the simulation are presented in Table 1. The selection of these values is completed by a computer program (See Appendix 4-4), which is designed for randomly indetifying a housing submarket system and the values of the parameters satisfying the equilibrium conditions (See Appendix 4-1).

Another computer program is implemented to undertake the simulation (See Appendix 4-5). This simulation is based on the parameter values randomly selected by the program in Appendix 4-4. The idea is: changing some of the parameter values to see if the system will be able to return to equilibrium from any disequilibrium position.

HOUSING SUBMARKET STRUCTURE

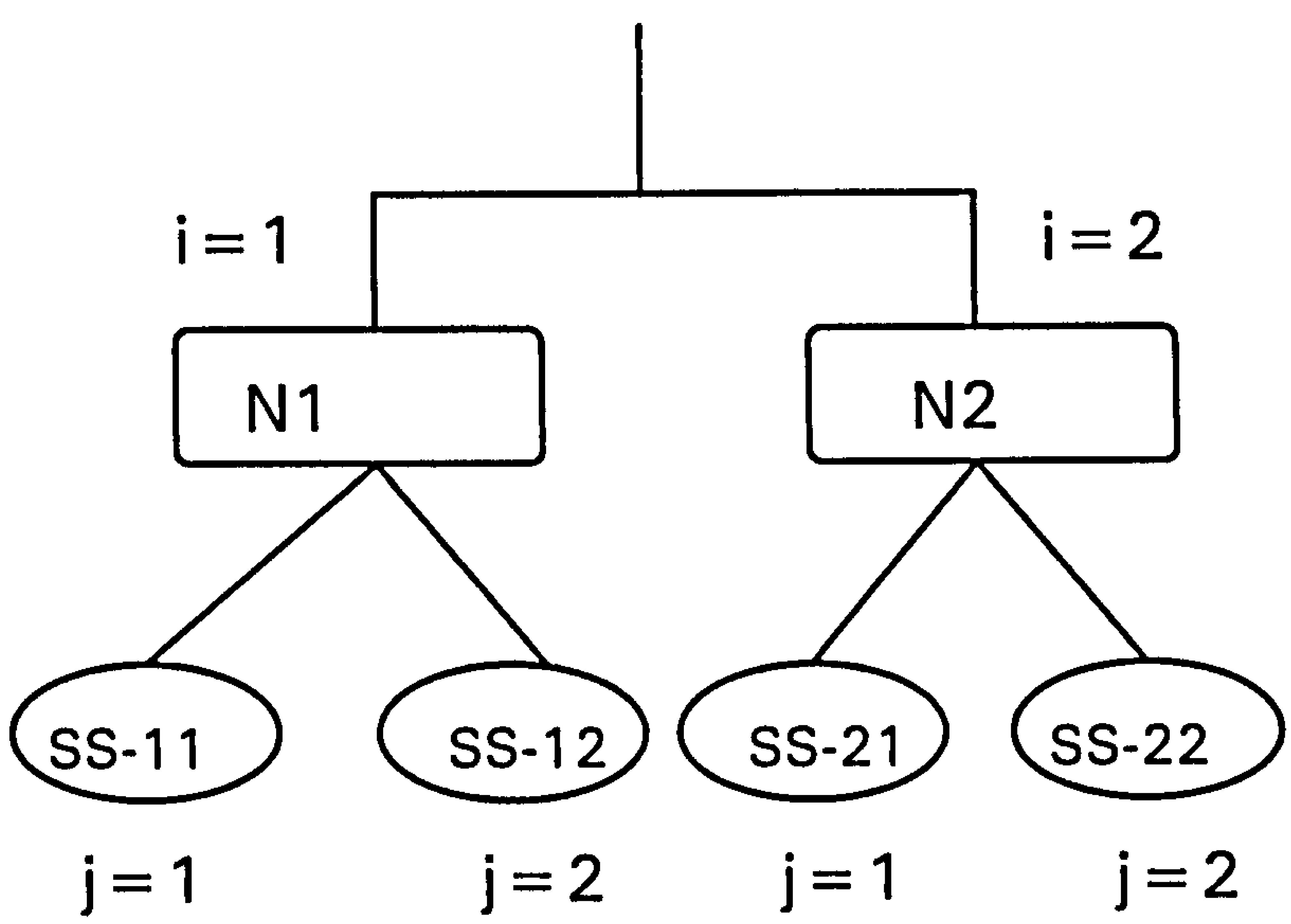


Table 1

An Example of Randomly Identified Nested Housing Submarket Structure

Para.	Value	Para.	Value	Para.	Value
β_{11}	0.4	γ^{1}_{11}	0.3	δ_{11}	4500
β_{12}	0.75	γ^{2}_{11}	0.2	δ_{12}	4000
β_{21}	0.5	γ^{1}_{12}	0.1	δ_{21}	6500
β_{22}	0.6	γ^{2}_{12}	0.1	δ_{22}	5000
ε_{11}	0.03	γ^{1}_{21}	0.1	χ_{11}	0.000
ε_{12}	0.02	γ^{2}_{21}	0.1	χ_{12}	0.000
ε_{21}	0.04	γ^{1}_{22}	0.2	χ_{21}	0.000
ε_{22}	0.02	γ^{2}_{22}	0.1	χ_{22}	0.000
D	7000	α_3*X	9	λ*Y_1	2.5
(1-σ)	0.44	α_3*X	3	λ*Y_2	1
α_1	-0.00	α_3*X	4		
α_2	-0.00	α_3*X	1		

Based on the above parameter values, the related housing submarket in equilibrium is given in Table 2.

Table 2

An Example of Housing Submarket in Equilibrium

Para.	Valu	Para.	Valu	Para.	Value (£)
$a_{11}=b_{11}=c_1$	1255	$d_{11}=s_{11}$	3139	p_{11}	127842.2
$a_{12}=b_{12}=c_1$	779	$d_{12}=s_{12}$	1038	p_{12}	93239.6
$a_{21}=b_{21}=b_2$	2407	$d_{21}=s_{21}$	4814	p_{21}	77031.6
$a_{22}=b_{22}=c_2$	967	d_{22}=s22	1612	p_{22}	51671.0
Pr_1	0.33	$Pr_{1/1}$	0.74	$Pr_{2/1}$	0.26
Pr_2	0.48	$Pr_{1/2}$	0.70	$Pr_{2/2}$	0.3
Pr_0	0.19				

In Appendixes 4-4 & 4-5, two programs are given for simulation. The correspondence of each array used in the programs to the parameters defined in Appendix 4-2 is given below.

For all i=1,2 ; j=1,2 and k=1,2:

Beta[2][2]=β_{ij};

Game[2][2][2]=γ_{ij}^{k};

Imsi[2][2]=ε_{ij};

Sigma[2][2]=δ_{ij};

Kai[2][2]=χ_{ij};

d=D;

alfa1=α_1 in the NMNL model;

alfa2=α_2 in the NMNL model;

alfa_cons[2][2]= α_3*X_{ij} in the NMNL model;

Coef_beta=1-σ in the NMNL model;

Beta_cons[2]=λ*Y_i in the NMNL model;

Ivalue[2]=exp(I_i) in the NMNL model;

Proj[2][2]=$Pr_{j/i}$ in the NMNL model;

Proi[2]=Pr_i in the NMNL model;

pij[2][2], pi[2]=p_{ij}, p_i;

qij[2][2]=q_{ij};

aij[2][2], ai[2]=a_{ij}, a_i;

bij[2][2], bi[2]=b_{ij}, b_i;

cij[2][2], ci[2]=c_{ij}, c_i;

dij[2][2], di[2]=d_{ij}, d_i;

sij[2][2], si[2]=s_{ij}, s_i.

Based on the values in Tables 1&2, three simulation cases are presented in Appendixes 4-6 to 4-8 seperately.

Appendix 4-4

The Program of Ramdomly Identifying A Housing Submarket System

/*This program is designed for randomly identifying a nested housing submarket system. The values in each array are a group of randomly selected initial values. Any change of these values will change the identification of the housing system, it means that a new housing submarket system is created.*/

```
double beta[2][2]={0.4,0.75},{0.5,0.6}};
double gama[2][2][2]={{0.3, 0.2,0.1,0.1},{0.1,0.1,0.2,0.1}};
double imsi[2][2]={{0.03,0.02},{0.04,0.02}};
double sigma[2][2]={{45000,40000},{65000,50000}};
double kai[2][2]={{0.00001,0.000015},{0.000015,0.00002}};
double d=7000;
double alfa1=-0.000085;
double alfa2=-0.006;
double alfa_cons[2][2]={{9,5},{4,1}};
double coef_beta=0.56;
double beta_cons[2]={2.5,1};
double proj[2][2],proi[2],proi0[2];
double proj1[2][2],proi1[2];
double ivalue[2];
double  pij[2][2],dij[2][2],sij[2][2];
double  qij[2][2],qi[2];
double a[2][2],b[2][2],c[2][2];
int i,i1,j,j1;
double x1,x2,x3,x4,x5,x6,x7;
```

/*This is a sub-program to calculate the conditional probability '$Pr_{j/i}$' (See Equation 3 in Chapter IV) in the NMNL model*/

```
double probability_type()
{
double x1,x2,y1,y2,z1,z2,z3,z4;

 z1=pij[i][0];
 z2=qij[i][0];
 z3=pij[i][1];
 z4=qij[i][1];
 x1=alfa1*z1+alfa2*z2+alfa_cons[i][0];
 x2=alfa1*z3+alfa2*z4+alfa_cons[i][1];
 y1=exp(x1);
 y2=exp(x2);
```

```
ivalue[i]=y1+y2;
if (j==0)
return (y1/ivalue[i]);
if (j==1)
return (y2/ivalue[i]);
}
```

/*This is a sub-program to calculate the marginal probability 'Pr$_i$'(See equation 4 in Chapter IV) in the NMNL model */

```
double probability_loca()
{
double x1,x2,y1,y2,z1,z2;
z1=log(ivalue[0]);
z2=log(ivalue[1]);
x1=coef_beta*z1+beta_cons[0];
x2=coef_beta*z2+beta_cons[1];
y1=exp(x1);
y2=exp(x2);
if (i==0)
return (y1/(y1+y2+1));
if (i==1)
return (y2/(y1+y2+1));
}
```

/*This is the main program*/

```
main()
{
FILE *fp;
fp=fopen("initial.dat","w");
```

/*Obtaining the equilibrium values of a housing submarket system*/

```
for (i=0;i<2;i++){
  for (j=0;j<2;j++) {
        qij[i][j]=1/(beta[i][j]);
        dij[i][j]=(imsi[i][j]*sigma[i][j])/(imsi[i][j]+beta[i][j]);
        sij[i][j]=dij[i][j];
  }
}
x1=0; x2=0; x3=0; x4=0; x5=0;
for (i=0;i<2;i++) {
  for (j=0;j<2;j++){
        x1+=imsi[i][j]*(sigma[i][j]-dij[i][j]);
        x4+=gama[i][j][1]*dij[i][j];
  }
}
```

```
for (i=0;i<2;i++) {
x2=0; x3=0; x5=0;
        for (j=0;j<2;j++) {
         x2+=imsi[i][j]*(sigma[i][j]-dij[i][j]);
        x3+=gama[i][j][1]*dij[i][j];
        x5+=(gama[i][j][0]+gama[i][j][1])*dij[i][j];
        }
proi0[i]=(x2+x3)/(d-x1);
proi[i]=(x2+x3)/(d+x4);
x6=imsi[i][0]*(sigma[i][0]-dij[i][0]);
        x6+=(gama[i][0][0]+gama[i][0][1])*dij[i][0];
x7=x2+x5;
        proj[i][0]=x6/x7;
x6=imsi[i][1]*(sigma[i][1]-dij[i][1]);
x6+=(gama[i][1][0]+gama[i][1][1])*dij[i][1];
 proj[i][1]=x6/x7;
 }

for (i=0;i<2;i++) {
        for (j=0;j<2;j++){
        x1=-(alfa_cons[i][j]+beta_cons[i]/coef_beta);
        x1+=-alfa2*qij[i][j]+(log(proi0[i]))/(coef_beta)+log(proj[i][j]);
        x2=x1/alfa1;
        pij[i][j]=x2;
        }
}
        for (i=0;i<2;i++) {
         for (j=0;j<2;j++) {
        proj1[i][j]=probability_type();
        }
}

 for (i=0;i<2;i++){
 proi1[i]=probability_loca();
 }

        for (i=0;i<2;i++) {
                for(j=0;j<2;j++){
         b[i][j]=beta[i][j]*dij[i][j];
                c[i][j]=imsi[i][j]*(sigma[i][j]-sij[i][j]);
                 x1=0;
                        for (j1=0;j1<2;j1++) {
                x1+=gama[i][j1][0]*dij[i][j1];
                        }
                x2=0;
        for (i1=0;i1<2;i1++) {
                for (j1=0;j1<2;j1++) {
```

```
            x2+=gama[i1][j1][1]*dij[i1][j1];
            }
        }
        a[i][j]=((d+x2)*proi[i]+x1)*proj[i][j]
        -(gama[i][j][0]+gama[i][j][1])*dij[i][j];
            }
        }

 /* Saving the results in the file of 'initial.dat'*/

system("clear");
        for (i=0;i<2;i++)  {
        for (j=0;j<2;j++) {
        printf("i=%d, j=%d\n, ",i,j);
        printf("beta=%15.3lf\n ",beta[i][j]);
        printf("qij=%15.3lf\n ",qij[i][j]);
        printf("prj=%15.3lf\n ",proj[i][j]);
        printf("prj1=%15.3lf\n ",proj1[i][j]);
        printf("a=%lf\n  ",a[i][j]);
        printf("b=%lf\n  ",b[i][j]);
        printf("c=%lf\n  ",c[i][j]);
        printf("pij=%lf\n  ",pij[i][j]);
        printf("dij=%lf\n  ",dij[i][j]);
        printf("sij=%lf\n  ",sij[i][j]);
        fprintf(fp,"i=%d, j=%d,\n ",i,j);
        fprintf(fp,"beta=%15.3lf\n ",beta[i][j]);
        fprintf(fp,"qij=%15.3lf\n ",qij[i][j]);
        fprintf(fp,"prj=%15.3lf\n ",proj[i][j]);
        fprintf(fp,"Prj1=%15.3lf\n",proj1[i][j]);
        fprintf(fp,"a=%lf\n  ",a[i][j]);
        fprintf(fp,"b=%lf\n  ",b[i][j]);
        fprintf(fp,"c=%lf\n  ",c[i][j]);
        fprintf(fp,"pij=%lf\n  ",pij[i][j]);
        fprintf(fp,"dij=%lf\n  ",dij[i][j]);
        fprintf(fp,"sij=%lf\n  ",sij[i][j]);
        printf("pri=%15.3lf\n ",proi[i]);
        printf("pri1=%15.3lf\n ",proi1[i]);
        printf("Ln(Inc)=%15.3lf\n ",log(ivalue[i]));
        fprintf(fp,"Pri=%15.3lf\n ",proi[i]);
        fprintf(fp,"pri1=%15.3lf\n ",proi1[i]);
        fprintf(fp,"Ln(Inc)=%15.3lf\n ",log(ivalue[i]));
            }
 }
fclose(fp);}
```

Appendix 4-5
The Simulation Program of a Nested Housing Submarket Operation

/*This program is designed for simulating the operation of a randomly identified nested housing submarket system. The values in each array are randomly identified by the program in Appendix 4-4. The meaning of each array used in the program is given in Appendix 4-3.*/

```
#define epsilon 1
double beta[2][2]={{0.4,0.75},{0.5,0.6}};
double gama[2][2][2]={{0.3,0.2,0.1,0.1},{0.1,0.1,0.2,0.1}};
double imsi[2][2]={{0.03,0.02},{0.04,0.02}};
double sigma[2][2]={{45000,40000},{65000,50000}};
double kai[2][2]={{0.00001,0.000015},{0.000015,0.00002}};
double d=7000;
double alfa1=-0.000085;
double alfa2=-0.006;
double alfa_cons[2][2]={{9,3},{4,1}};
double coef_beta=0.56;
double beta_cons[2]={2.5,1};
double proj[2][2],proi[2];
double ivalue[2];
double pij[2][2]={{151612.07,115508.56},{76191.27,50830.65}};
double pi[2];
double qij[2][2],qi[2];
double dij[2][2]={{3139.53,1038.96},{4814.81,1612.90}};
double sij[2][2]={{3139.53,1038.96},{4814.81,1612.90}};
double a[2][2],b[2][2],c[2][2];
```

/*This is a sub-program to calculate the conditional probability: '$Pr_{j/i}$' (See Equation 3 in Chapter IV) in the NMNL model */

```
int i,j;
double probability_type()
{
double x1,x2,y1,y2,z1,z2,z3,z4;

 z1=pij[i][0];
 z2=qij[i][0];
 z3=pij[i][1];
 z4=qij[i][1];
 x1=alfa1*z1+alfa2*z2+alfa_cons[i][0];
  x2=alfa1*z3+alfa2*z4+alfa_cons[i][1];
```

```
y1=exp(x1);
 y2=exp(x2);
ivalue[i]=y1+y2;
if (j==0)
return (y1/ivalue[i]);
 if (j==1)
 return (y2/ivalue[i]);
}
```

/*This is a sub-program to calculate the marginal probability 'Pr$_i$' (See Equation 2 in Chapter IV) in the NMNL model */

```
double probability_loca()
{
double x1,x2,y1,y2,z1,z2;

z1=log(ivalue[0]);
z2=log(ivalue[1]);
x1=coef_beta*z1+beta_cons[0];
x2=coef_beta*z2+beta_cons[1];
y1=exp(x1);
y2=exp(x2);
if (i==0)
return (y1/(y1+y2+1));
 if (i==1)
return (y2/(y1+y2+1));
}
```

/*This is the main program*/

```
main()
{
FILE *fpd1; FILE *fpd2; FILE *fpd3; FILE *fpd4;
FILE *fps1;  FILE *fps2; FILE *fps3;  FILE *fps4;
FILE *fpp1;  FILE *fpp2; FILE *fpp3; FILE *fpp4;
FILE *fp;

int test=1, t=0, check=0, num_run=1000, i1,i2,j1,j2;
double x1,x2,x3;

printf("Please input run_num:");
scanf("%d",&num_run);
fpd1=fopen("resultd1.dat","w"); fpd2=fopen("resultd2.dat_d2","w");
fpd3=fopen("resultd3.dat","w"); fpd4=fopen("resultd4.dat","w");
fps1=fopen("results1.dat","w");  fps2=fopen("results2.dat","w");
fps3=fopen("results3.dat","w");  fps4=fopen("results4.dat","w");
fpp1=fopen("resultp1.dat","w"); fpp2=fopen("resultp2.dat","w");
fpp3=fopen("resultp3.dat","w"); fpp4=fopen("resultp4.dat","w");
```

```
fp=fopen("rtest.dat","w");
```

/*This is to calculate the initial choice probabilities*/

```
for (i=0;i<2;i++){
        for (j=0;j<2;j++) {
         x1=dij[i][j]-sij[i][j];
                if ((x1<0)&&(fabs(x1)>epsilon))
        qij[i][j]=(sij[i][j]/(beta[i][j]*dij[i][j]));
                if ((x1>0)||(fabs(x1)<=epsilon))
        qij[i][j]=1 / (beta[i][j]);
                }
 }


        for (i=0;i<2;i++) {
                for (j=0;j<2;j++) {
        proj[i][j]=probability_type();
                }
        }


        for (i=0;i<2;i++){
                proi[i]=probability_loca();
        }
```

/*This 'While' sentence is used to control the simulation times, which represents the time that the market will take to return to equilibrium*/

```
while ((test !=0)&&(check<num_run)) {

 for (i=0;i<2;i++) {
        for (j=0;j<2;j++)  {
         x2=dij[i][j]-sij[i][j];
        if ((x2<0)||(fabs(x2)<epsilon))
        b[i][j]=
        beta[i][j]*dij[i][j];
        else
        b[i][j]=
        beta[i][j]*sij[i][j];
        c[i][j]=imsi[i][j]*(sigma[i][j]-sij[i][j]);
         x2=0;
        for (j2=0;j2<2;j2++) {
         x2+=gama[i][j2][0]*dij[i][j2];
         }
        x3=0;
        for (i1=0;i1<2;i1++)  {
                for (j1=0;j1<2;j1++)  {
```

```
                x3+=gama[i1][j1][1]*dij[i1][j1];
                }
        }
        a[i][j]=
         ((d+x3)*proi[i]+x2)*proj[i][j]-
         (gama[i][j][0]+gama[i][j][1])*dij[i][j];
        }
        }

        for (i=0;i<2;i++) {
                for (j=0;j<2;j++) {
         x2=dij[i][j]-sij[i][j];
        pij[i][j]+=kai[i][j]*x2*pij[i][j];
         dij[i][j]+=a[i][j]-b[i][j];
        sij[i][j]+=c[i][j]-b[i][j];
         x2=dij[i][j]-sij[i][j];
         if((x2<0) && (fabs(x2)>epsilon))
        qij[i][j]=sij[i][j]/(beta[i][j]*dij[i][j]);
        if((x2>0) || (fabs(x2)<=epsilon))
        qij[i][j]=1 / (beta[i][j]);
                }
        }

        for (i=0;i<2;i++) {
        for (j=0;j<2;j++) {
         proj[i][j]=probability_type();
         }
         }

for (i=0;i<2;i++) {
proi[i]=probability_loca();
 }

/*This is to test if the market achieves in equilibrium*/

test=0;
for (i=0;i<2;i++) {
         for (j=0;j<2;j++) {
        x1=fabs(a[i][j]-b[i][j]);
         x3=fabs(a[i][j]-c[i][j]);
        x2=fabs(dij[i][j]-sij[i][j]);
        if((x1>1)||(x2>1)||(x3>1))
        test=test+1;
         }
         }
printf("test=%d\n", test);

/* Saving this group of simulation results*/
```

```
t++;
system("clear");
printf("t= %d\n",t);
fprintf(fp,"%d\n",test);
for (i=0;i<2;i++) {
        for (j=0;j<2;j++) {
        if (i==0 && j==0){
        fprintf(fpd1,"%lf\n",dij[i][j]);
        fprintf(fps1,"%lf\n",sij[i][j]);
        fprintf(fpp1,"%lf\n",pij[i][j]);
        }
        if (i==0 && j==1){
        fprintf(fpd2,"%lf\n",dij[i][j]);
        fprintf(fps2,"%lf\n",sij[i][j]);
        fprintf(fpp2,"%lf\n",pij[i][j]);
        }
        if (i==1 && j==0){
        fprintf(fpd3,"%lf\n",dij[i][j]);
        fprintf(fps3,"%lf\n",sij[i][j]);
        fprintf(fpp3,"%lf\n ",pij[i][j]);
        }
        if (i==1 && j==1){
        fprintf(fpd4,"%lf\n",dij[i][j]);
        fprint(fps4,"%lf\n",sij[i][j]);
        fprintf(fpp4,"%lf\n",pij[i][j]);
        }
        }
    }

check++;
} /*End of the 'While' sentence*/
fclose(); }
```

Appendix 4-6
Simulation Case One: towards equilibrium

This simulation is based on the nested housing submarket structure identified in Appendix 4-3. Some changes are:

1. the sectoral housing submarket (SS- 11, 12, 21, 22) characteristics are measured by: alfa_cons[2][2]= {(9,3),(4,1)};

2. the neighbourhood submarket (N- 1, 2) characteristics are measured by: beta_cons[2]= {2.5, 1}.

3. the sectoral housing submarket equilibrium prices are: p[2][2]={(150111.07, 91979.14), (52661.86, 27301.24)}.

The average scaled standard deviation of the submarket house prices is 0.66.
Simulation result: housing submarket equilibrium has neighbourhood stability.

An example is given below to show the dynamic process to equilibrium after the housing price in submarket-11 is increased 1% from the equilibrium price.

DAMAGED TEXT IN ORIGINAL

1. The dynamic processes of the buyers' housing choice probabilities for the different housing submarkets.

Diagram 1

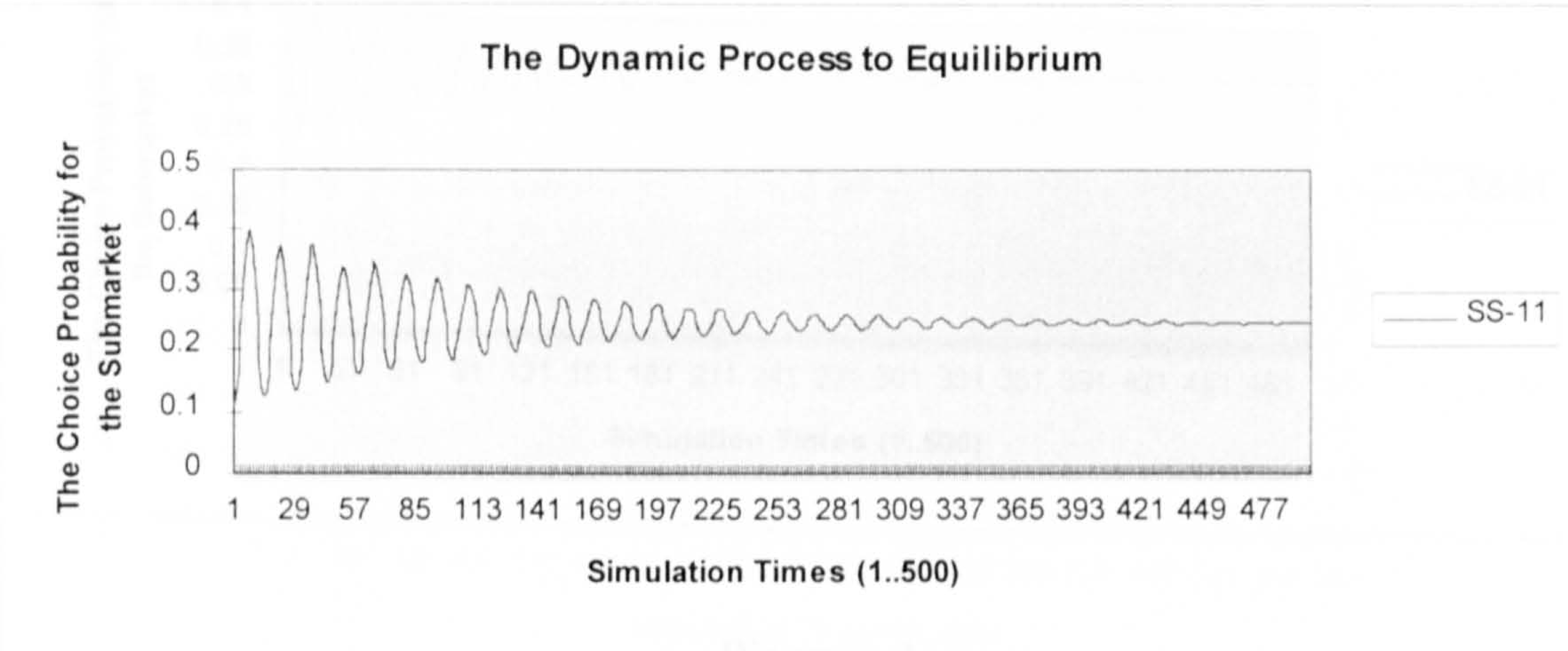


Diagram 2

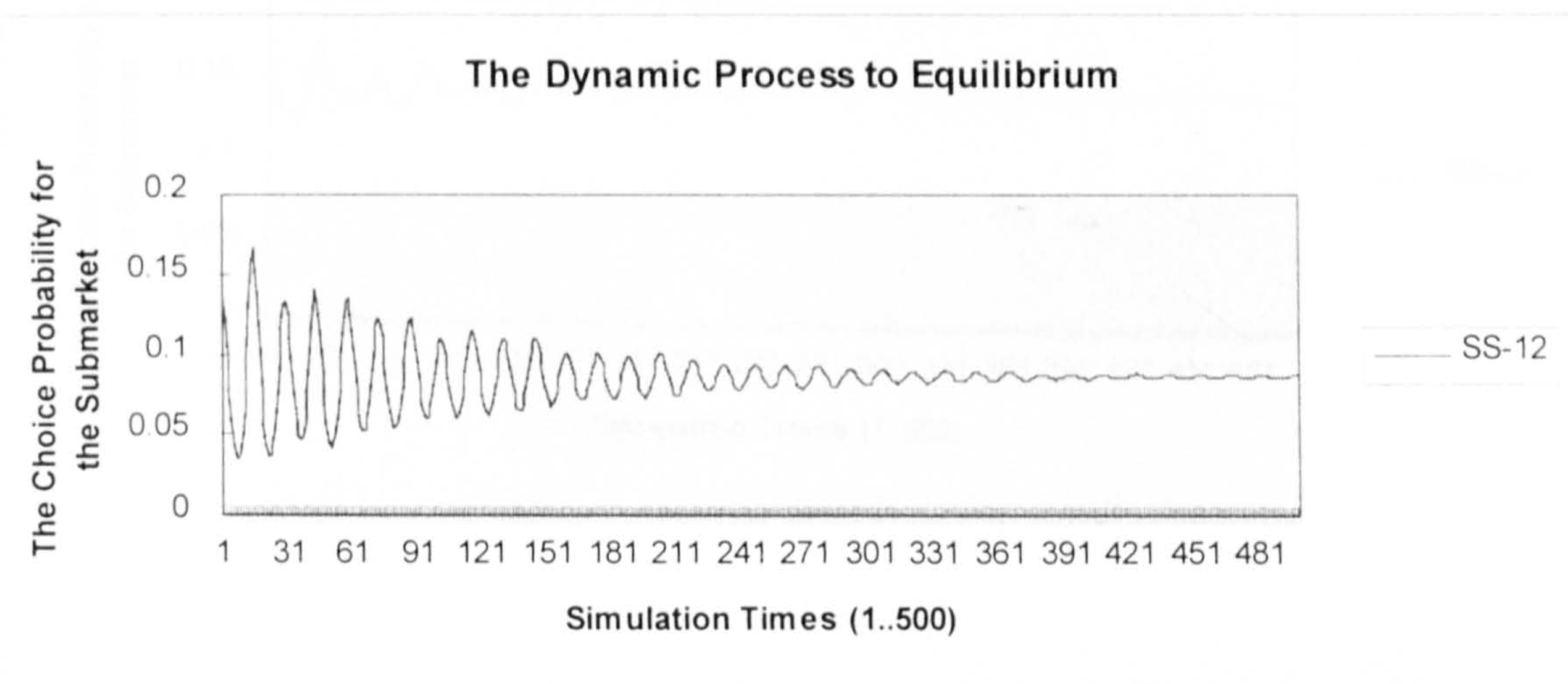


Diagram 3

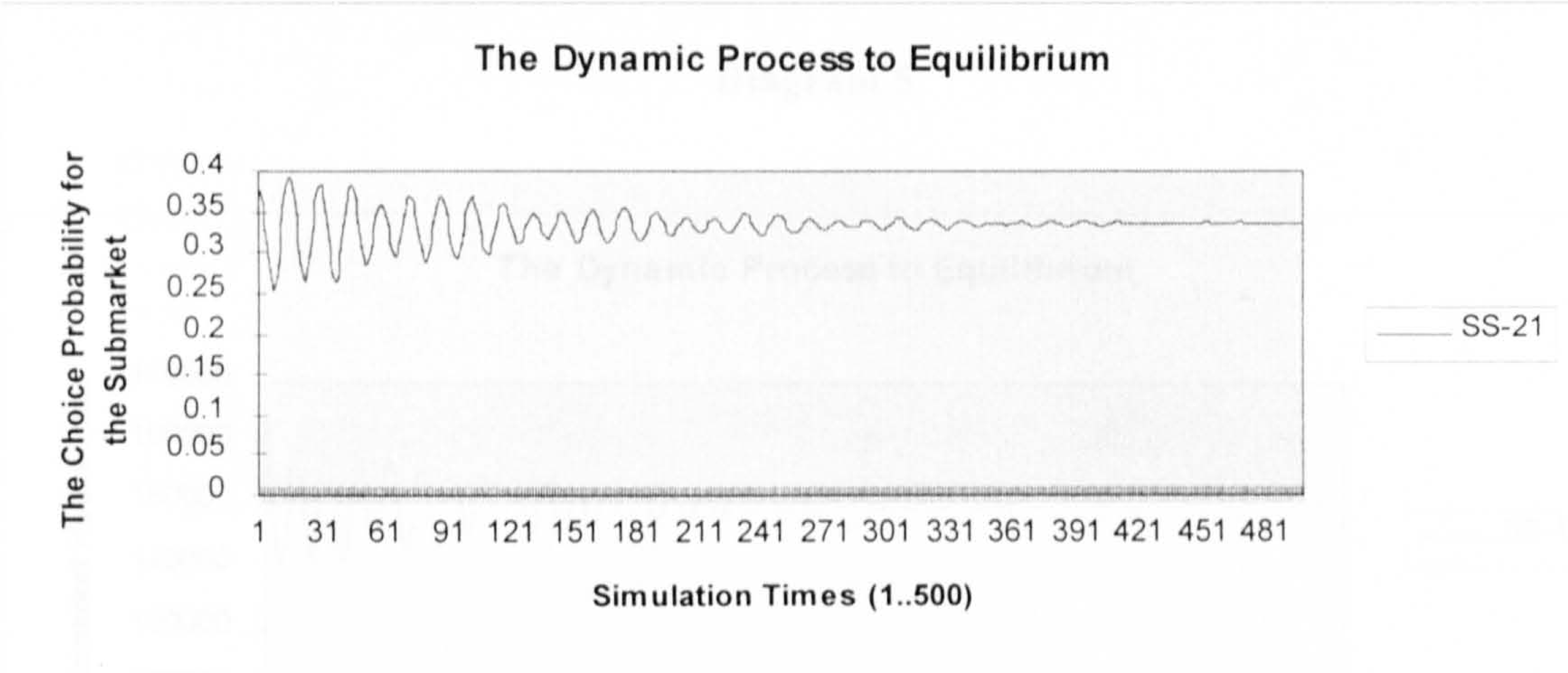
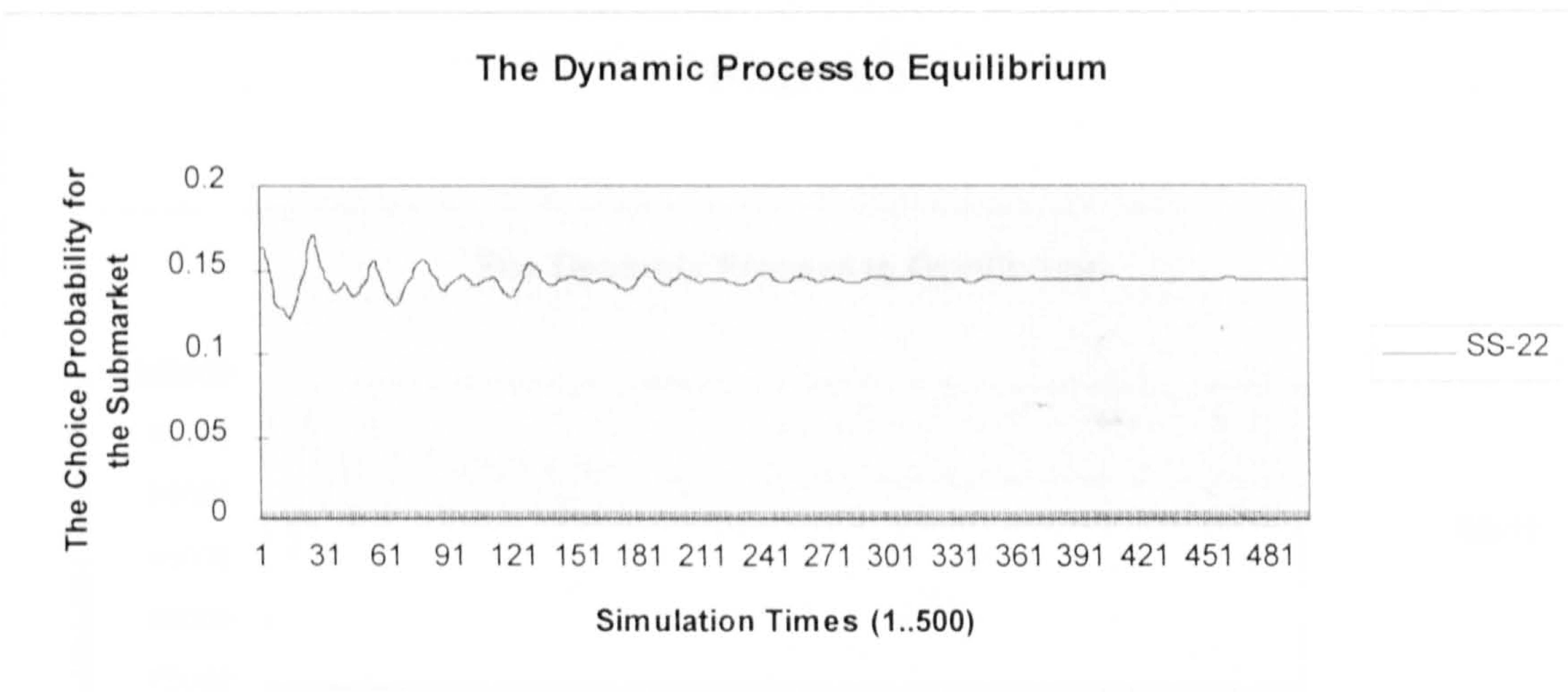


Diagram 4



2. The dynamic processes of the submarket housing prices to equilibrium

Diagram 5

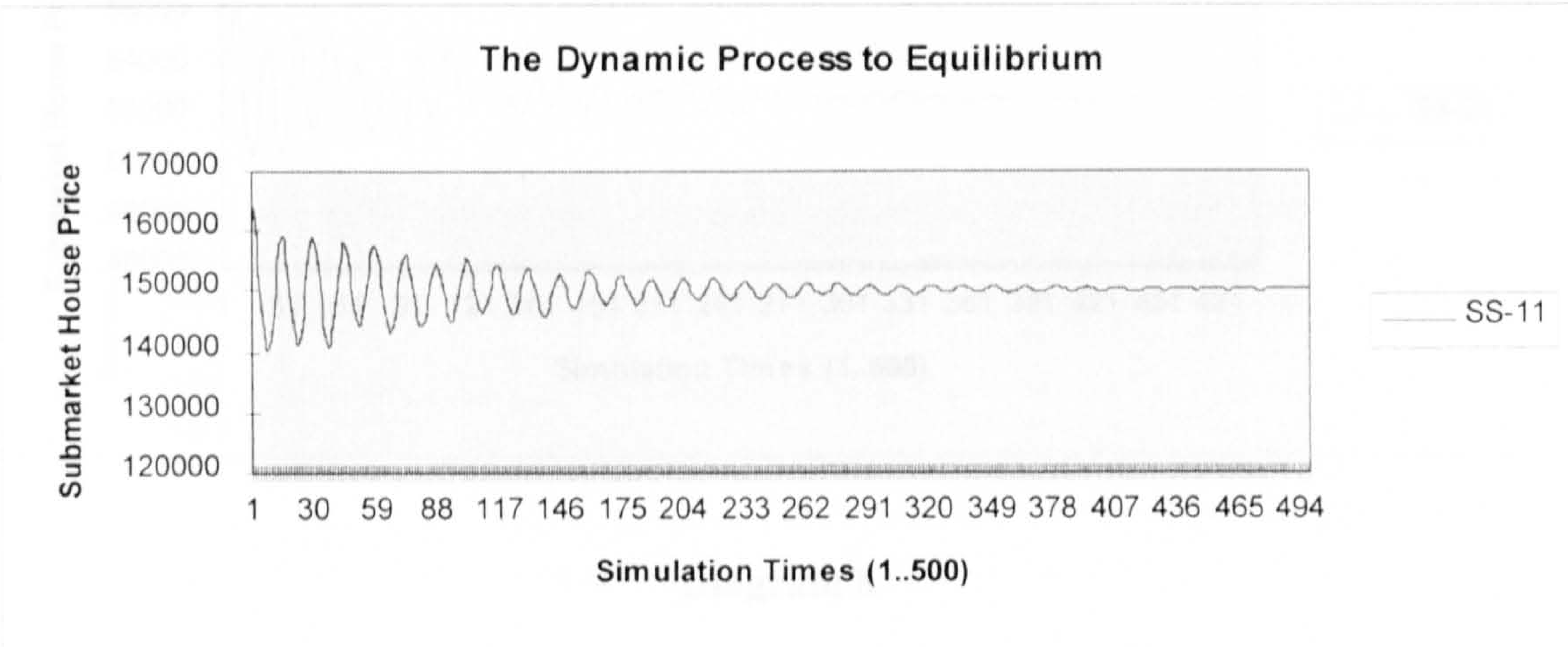


Diagram 6

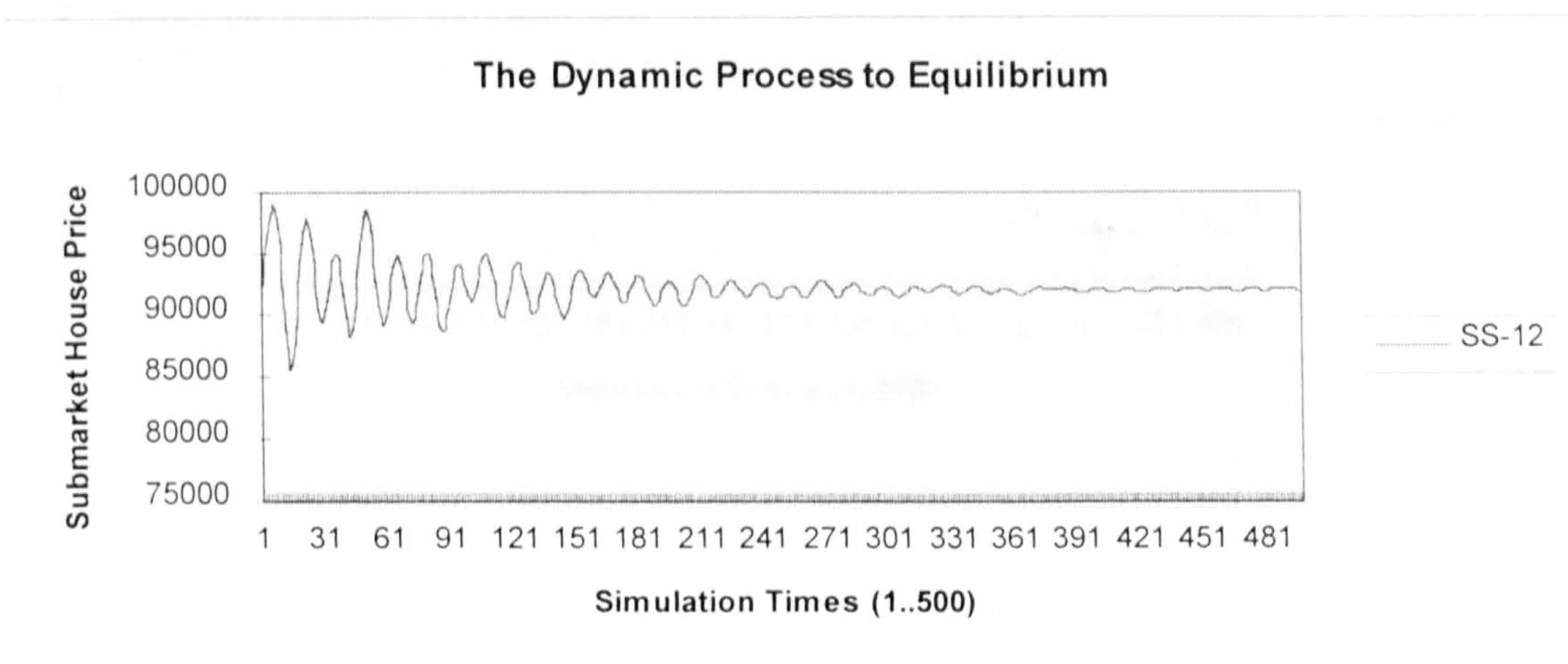


Diagram 7

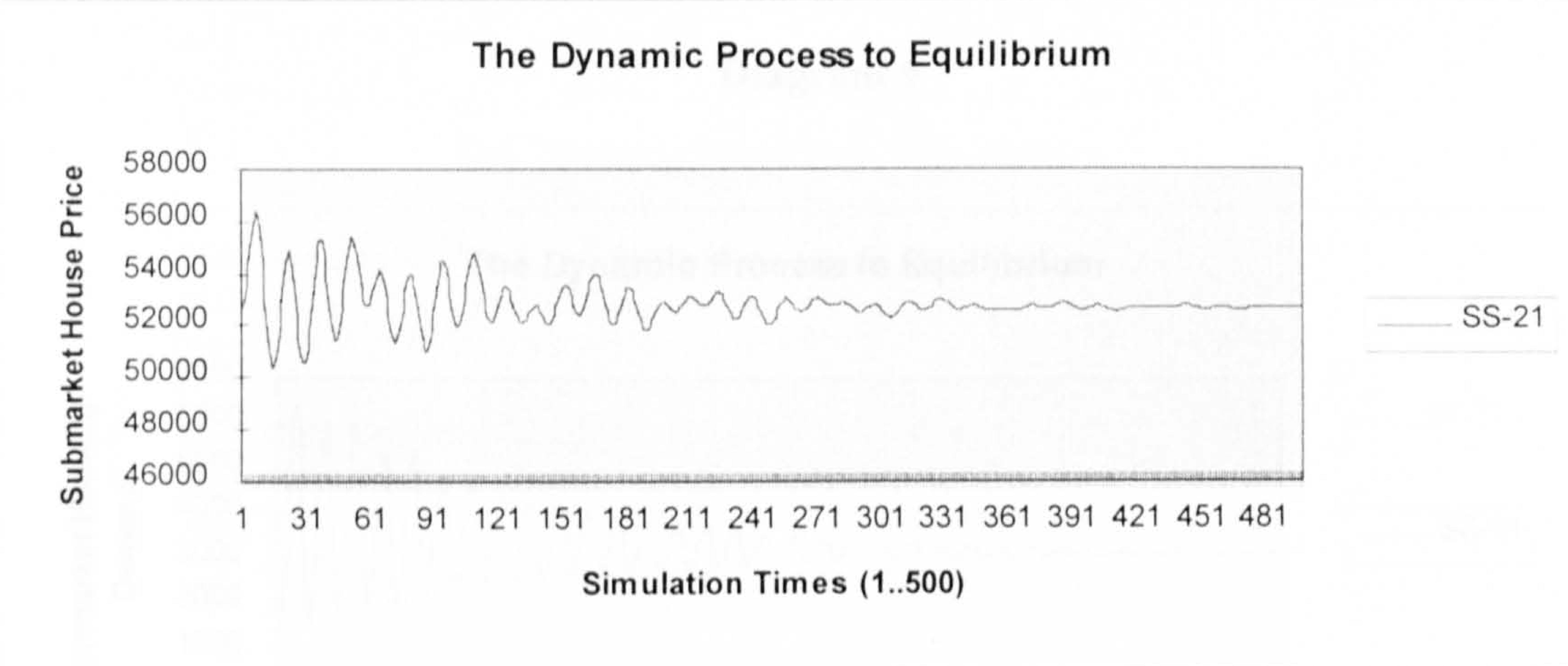
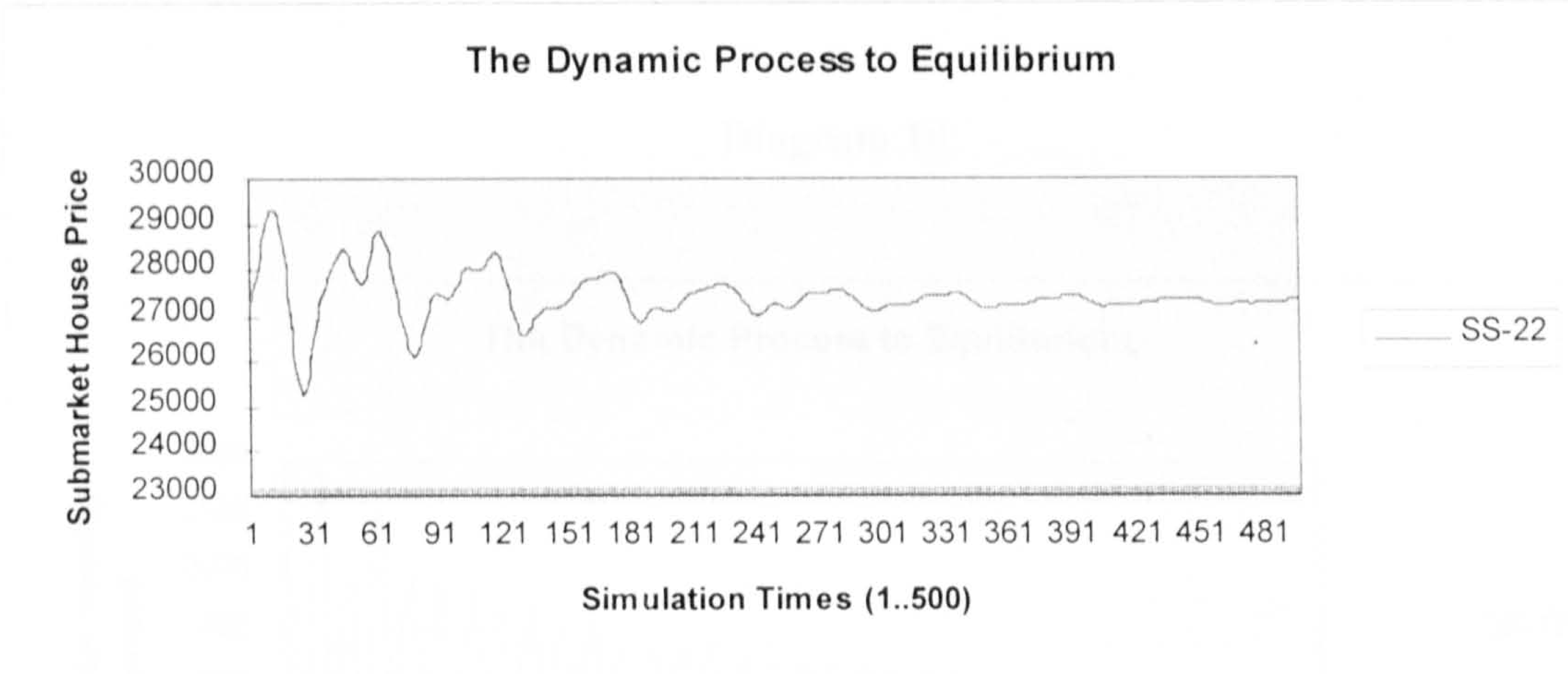


Diagram 8



3. The dynamic processes of the submarket housing demands to equilibrium

Diagram 9

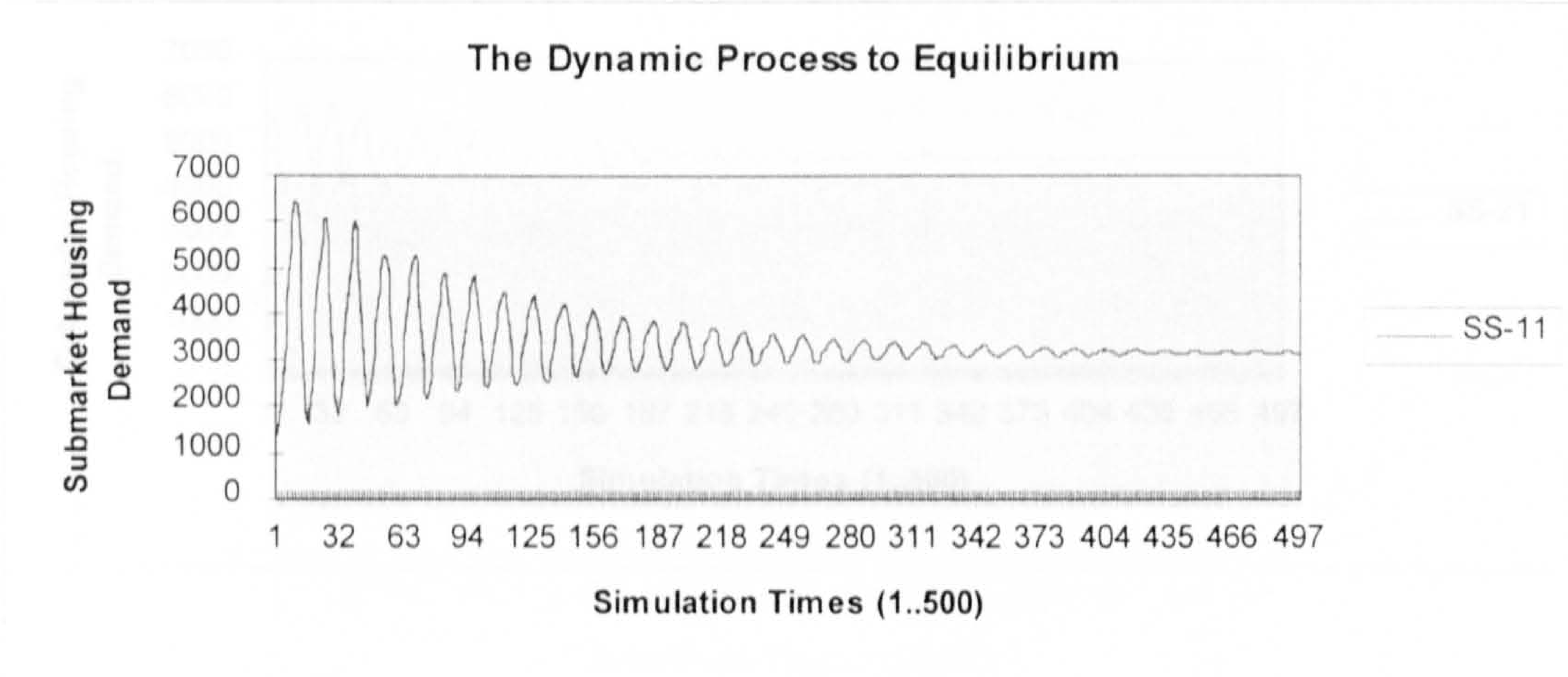


Diagram 10

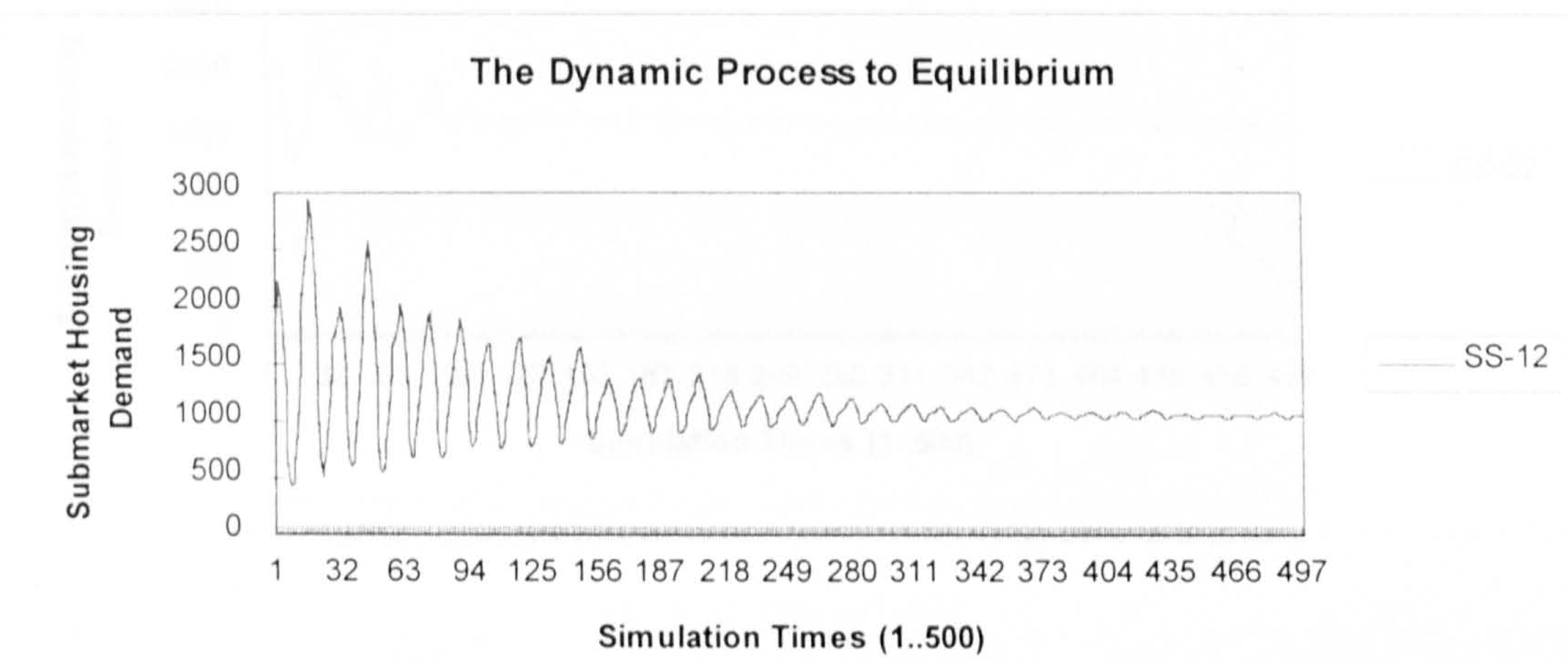


Diagram 11

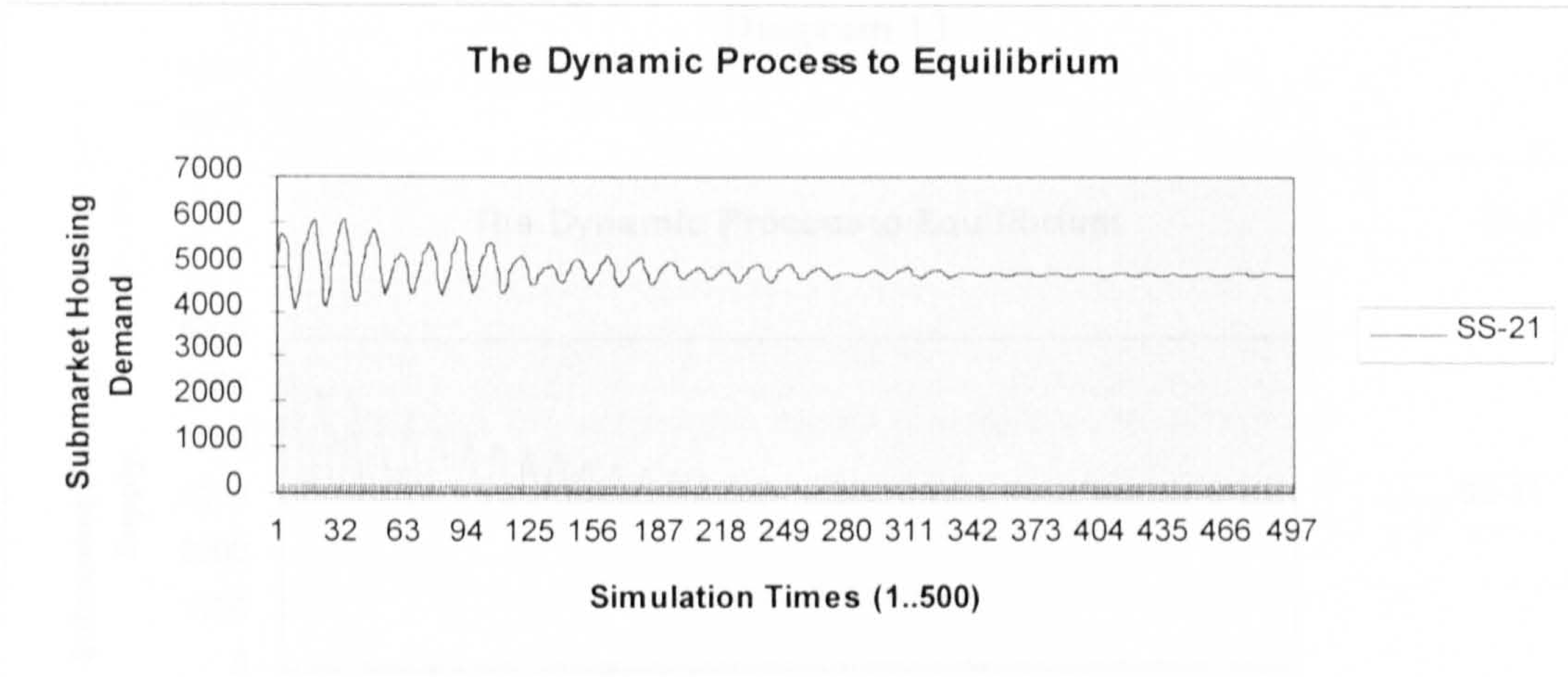
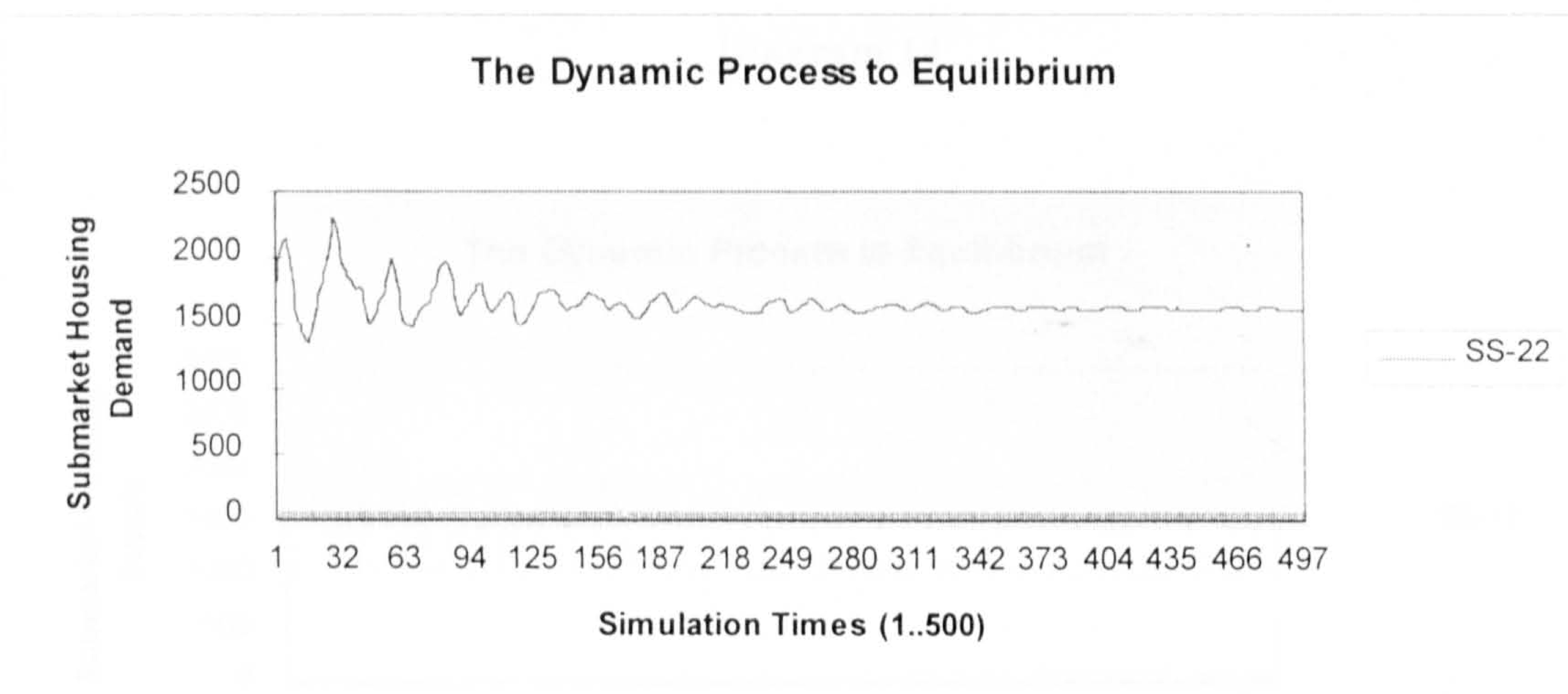


Diagram 12



4. The dynamic processes of the submarket housing supplies to equilibrium

Diagram 13

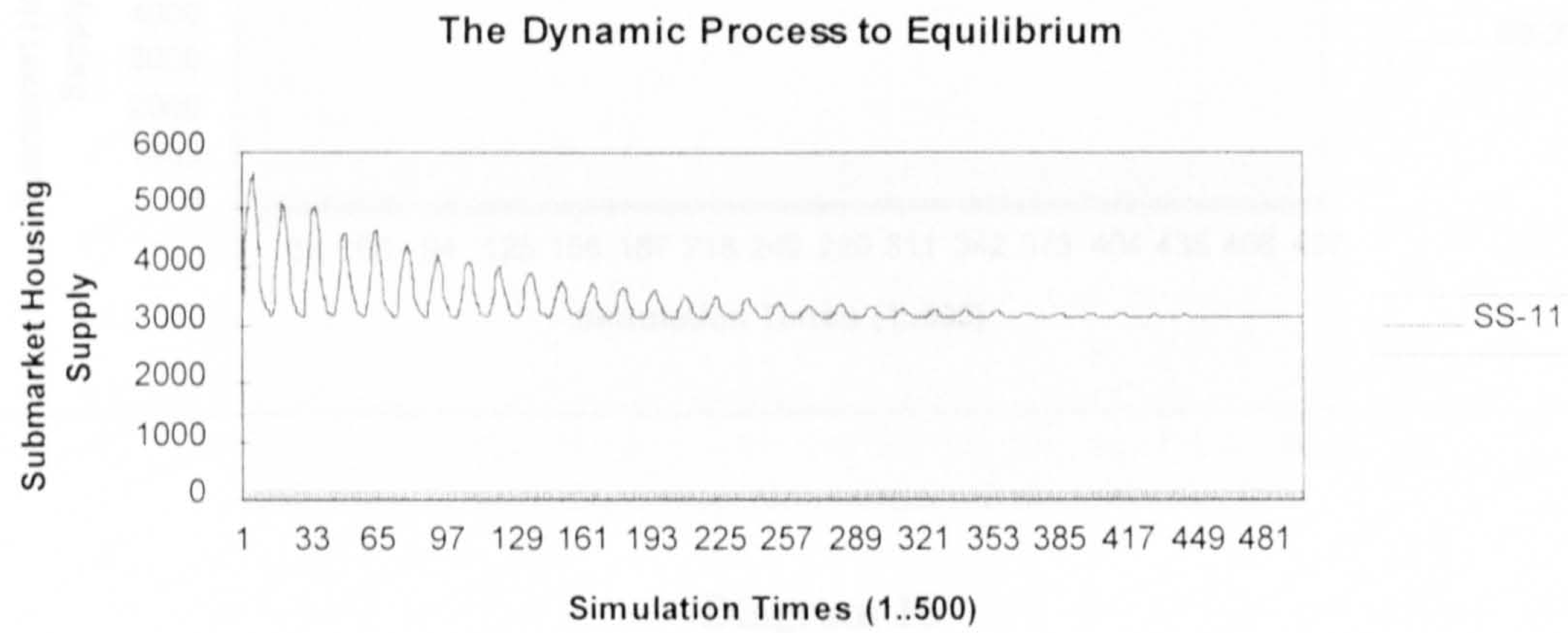


Diagram 14

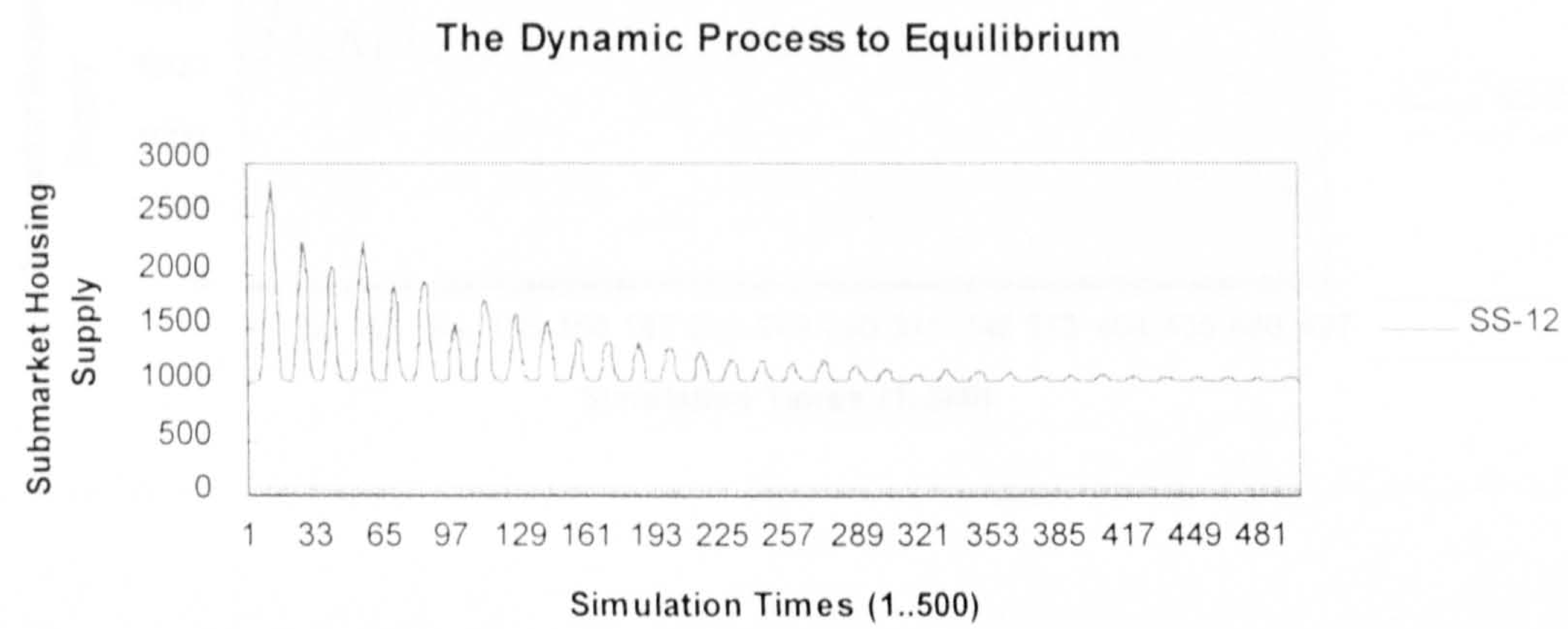


Diagram 15

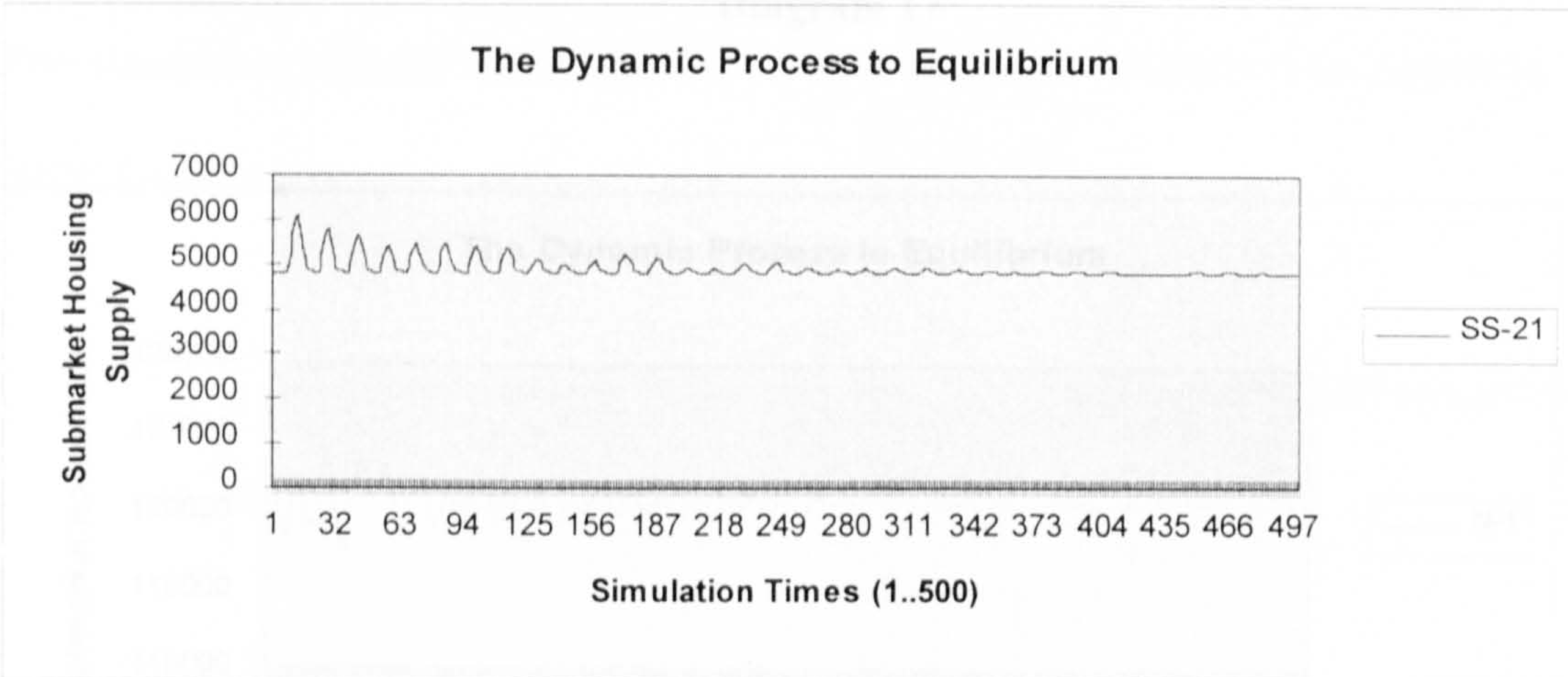
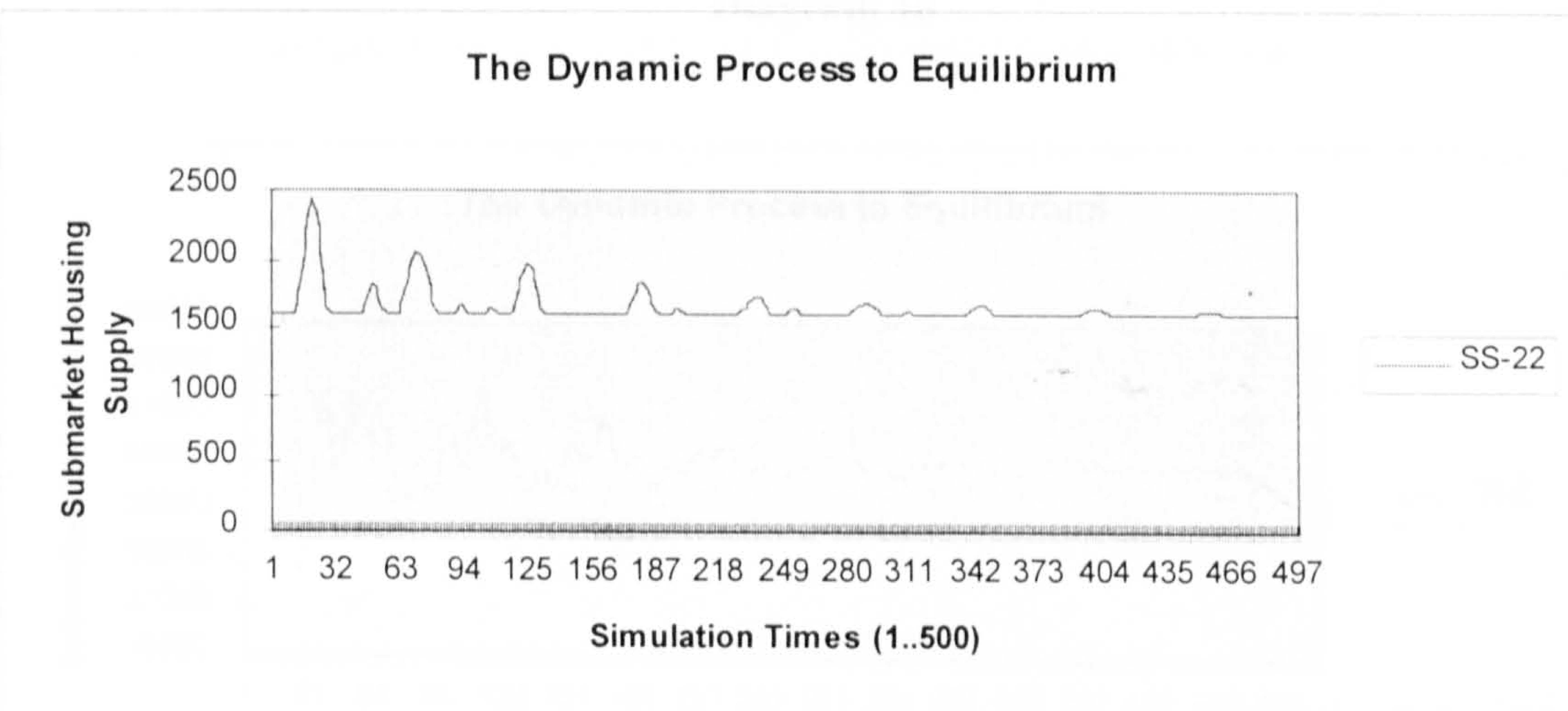


Diagram 16



5. The dynamic processes of the neighbourhood housing prices to equilibrium

Diagram 17

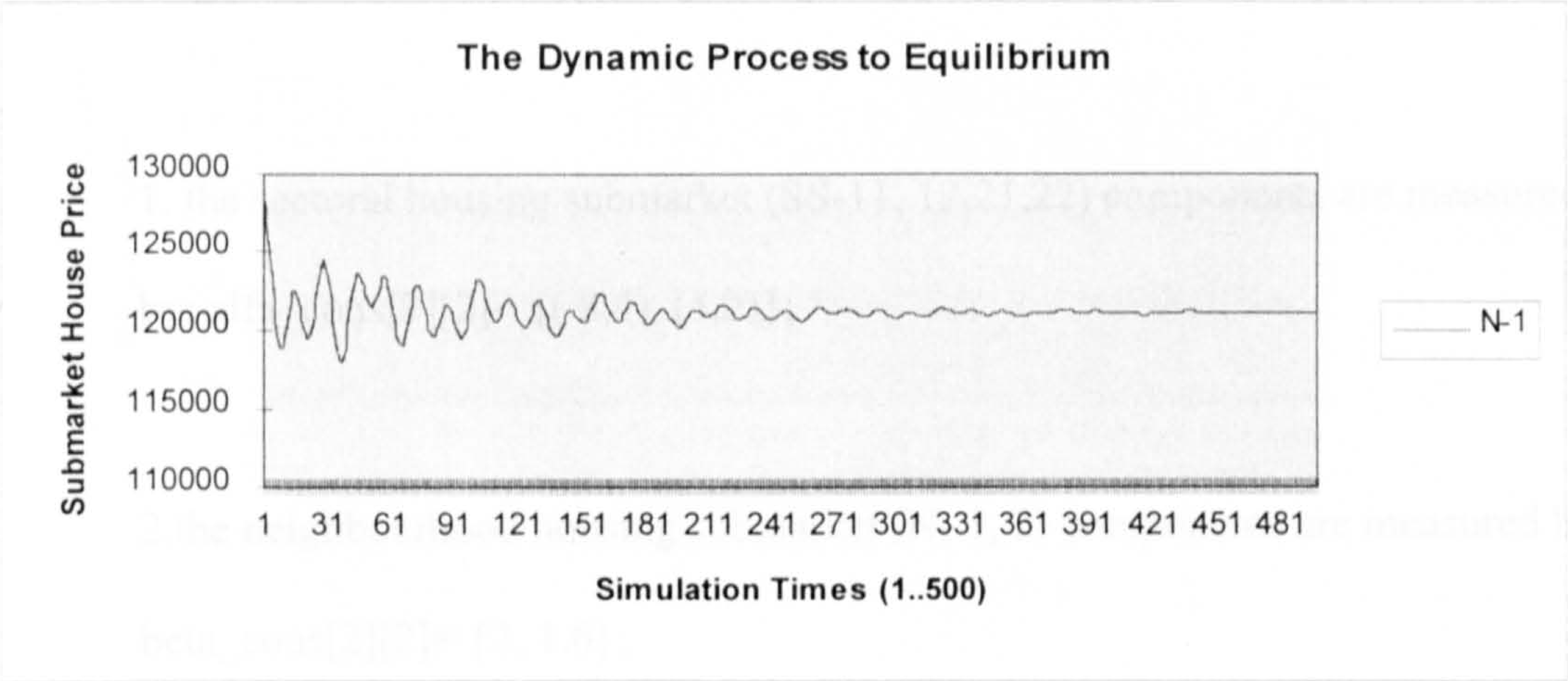
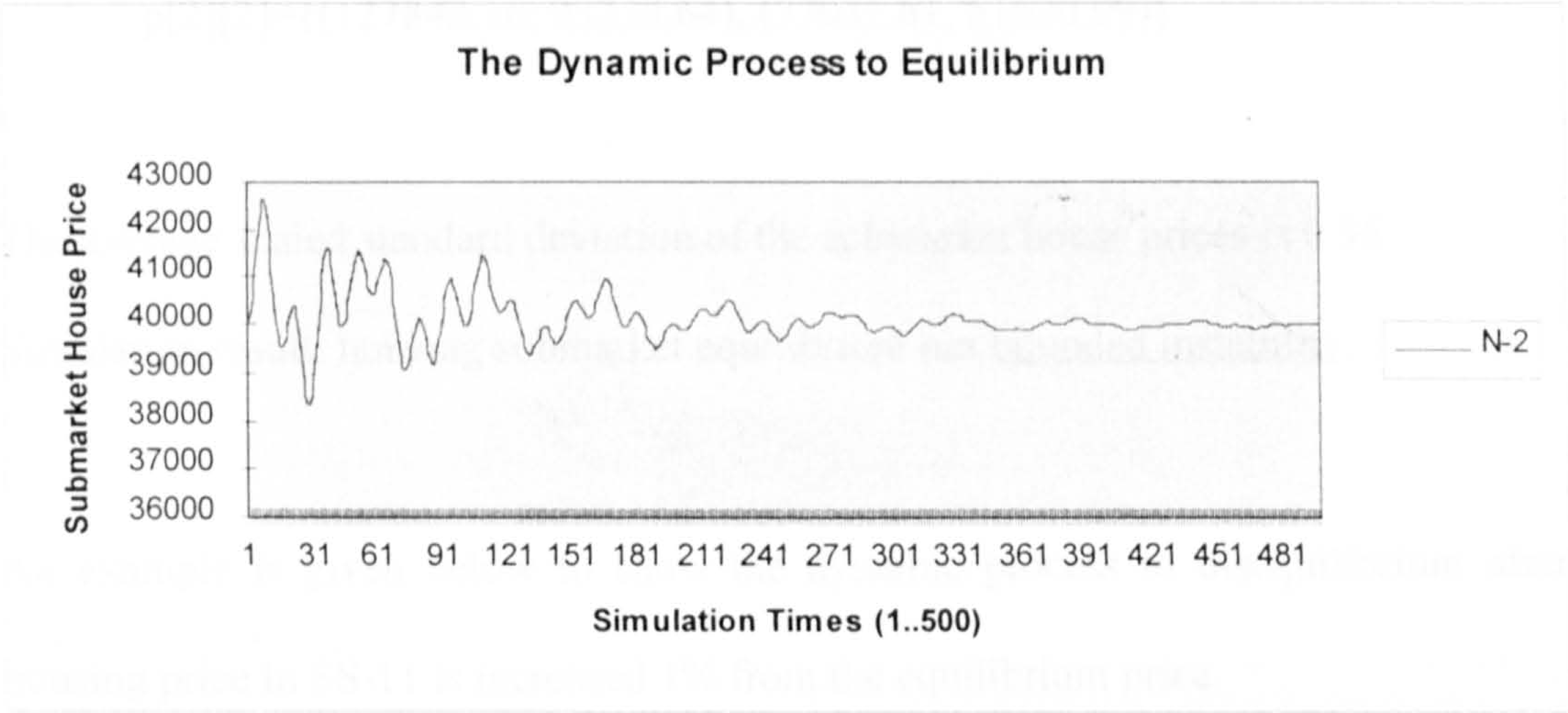


Diagram 18



Appendix 4-7
Simulation Case Two: towards disequilibrium (1)

The simulation is based on the nested housing submarket identified in Appendix 4-3. Some changes are:

1. the sectoral housing submarket (SS-11, 12,21,22) components are measured by: alfa_cons[2][2]= {(8,4), (5,2)};

2.the neighbourhood housing submarket (N- 1, 2) components are measured by: beta_cons[2][2]= {2, 1.6};

3. the sectoral housing submarket equilibrium house prices are: p[2][2]={(127842.16, 93239.64), (77031.61, 51670.99)}

The average scaled standard deviation of the submarket house prices is 0.36.

Simulation result: housing submarket equilibrium has bounded instability.

An example is given below to show the dynamic process to disequilibrium after the housing price in SS-11 is increased 1% from the equilibrium price.

1. The dynamic processes of the buyers' housing choice probabilities for the different housing submarket to disequilibrium

Diagram 1

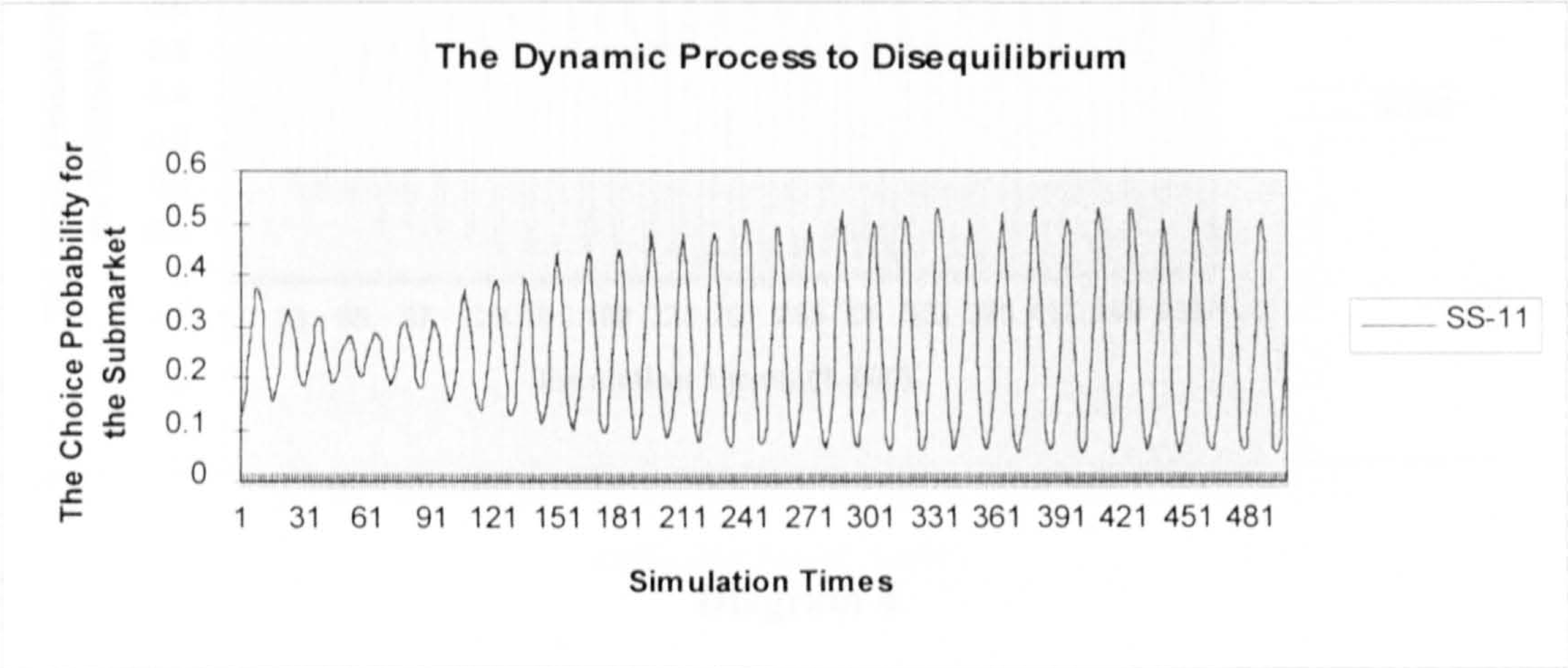


Diagram 2

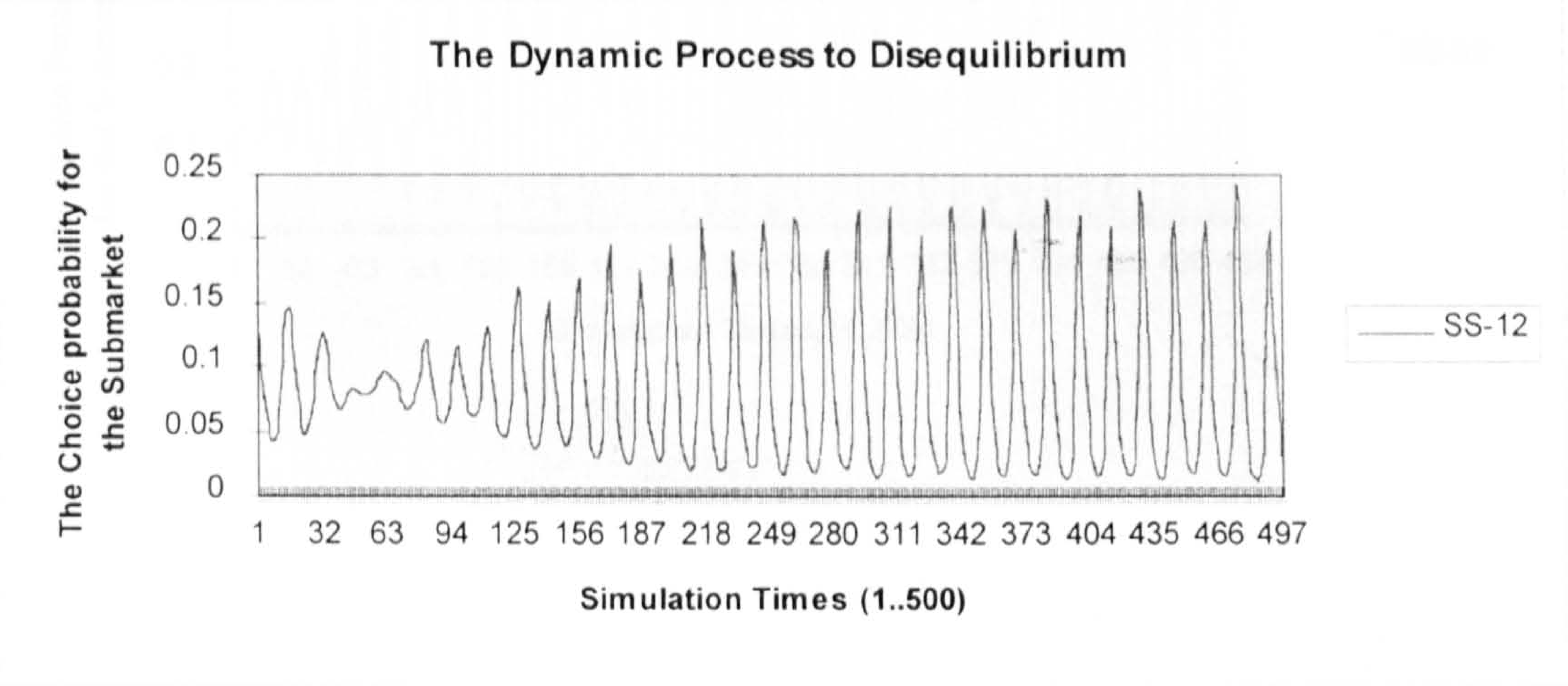


Diagram 3

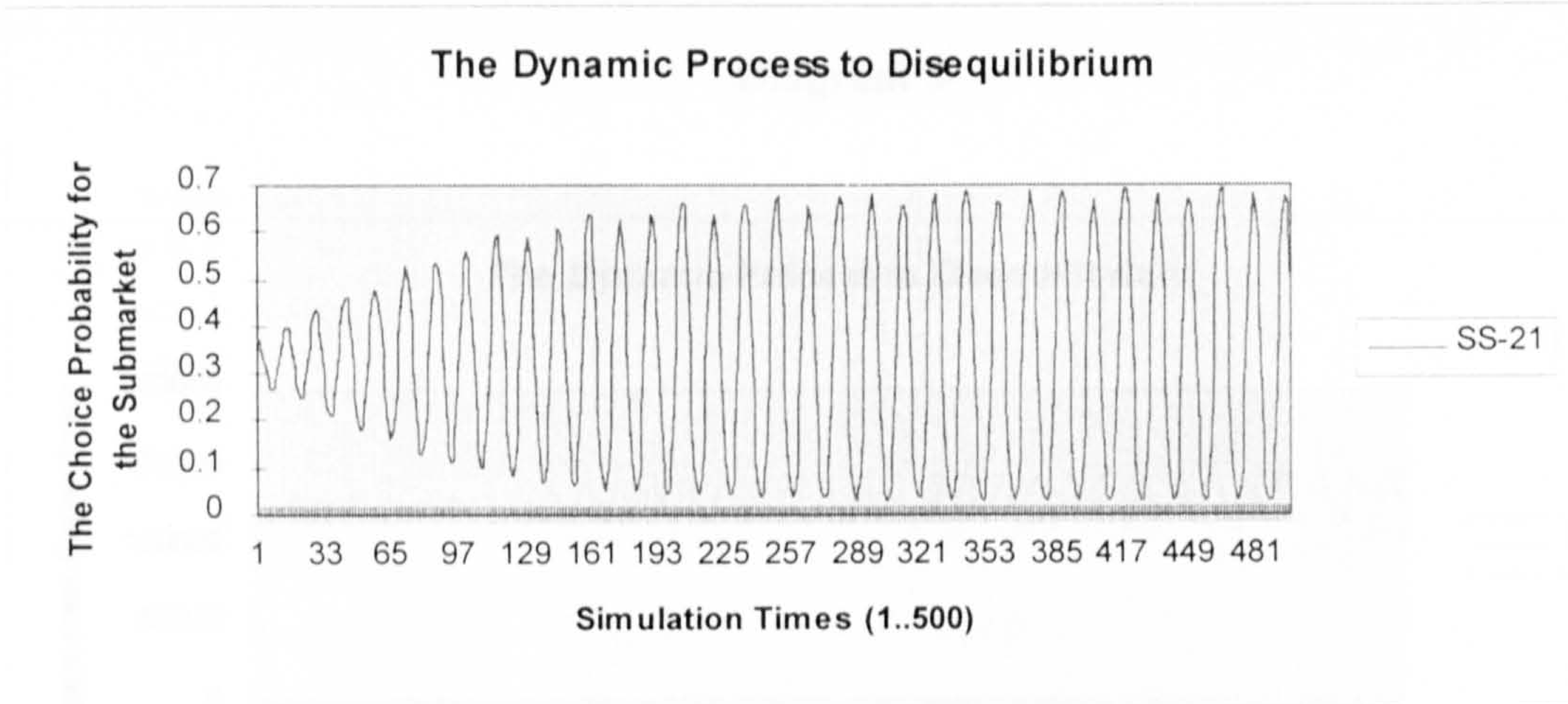
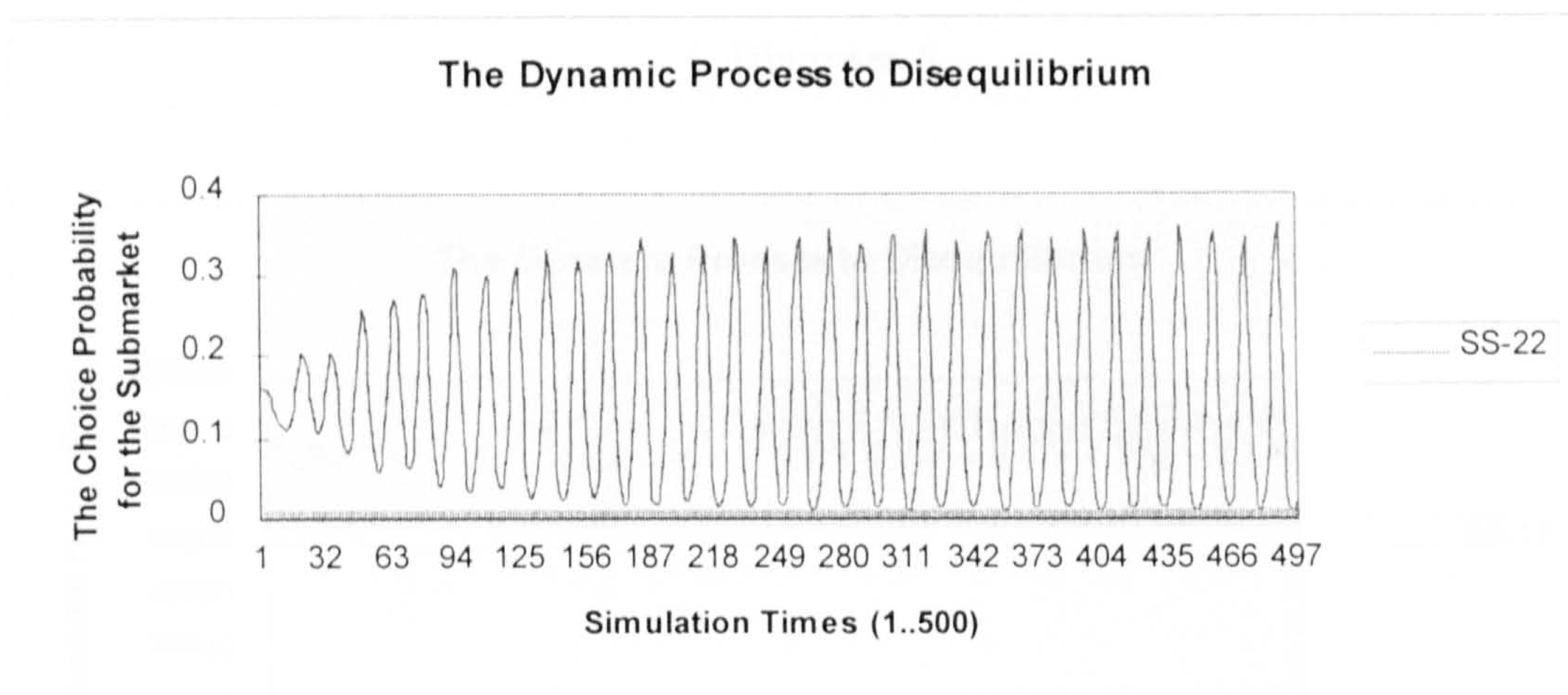


Diagram 4



2. The dynamic processes of the submarket housing prices to disequilibrium

Diagram 5

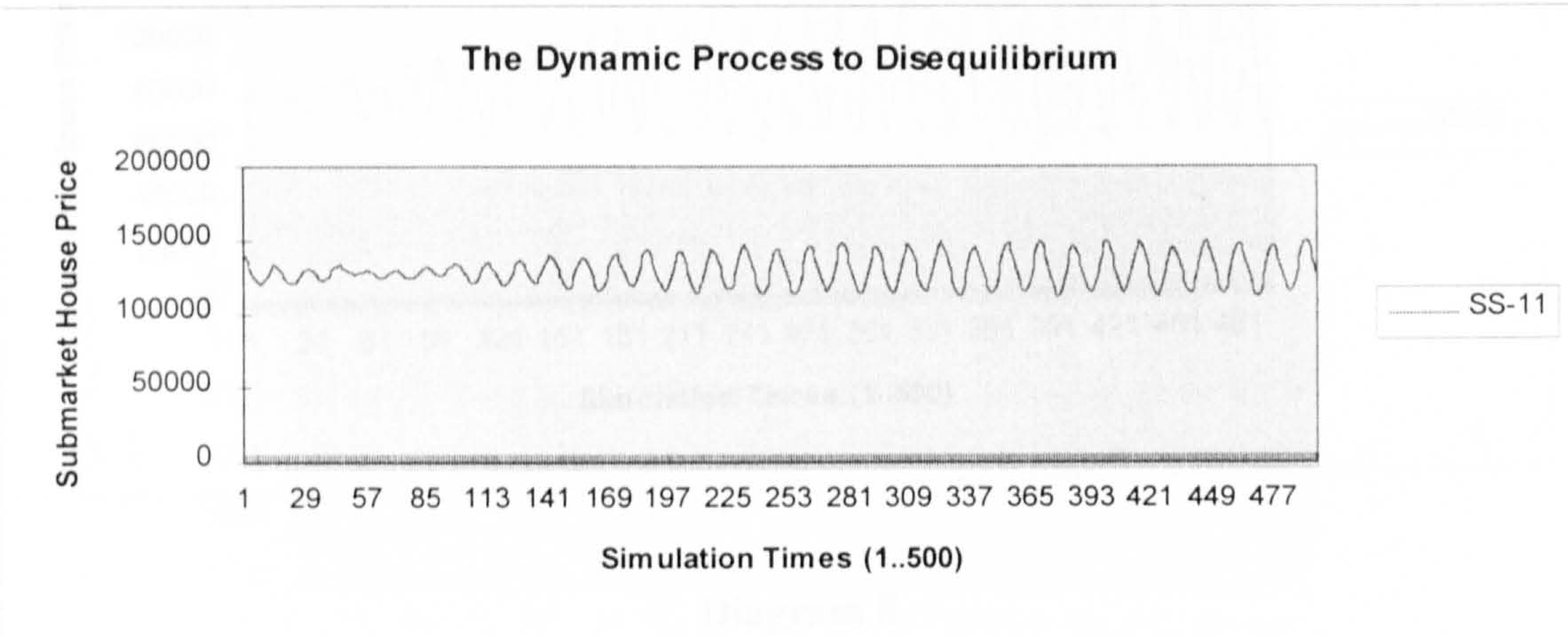


Diagram 6

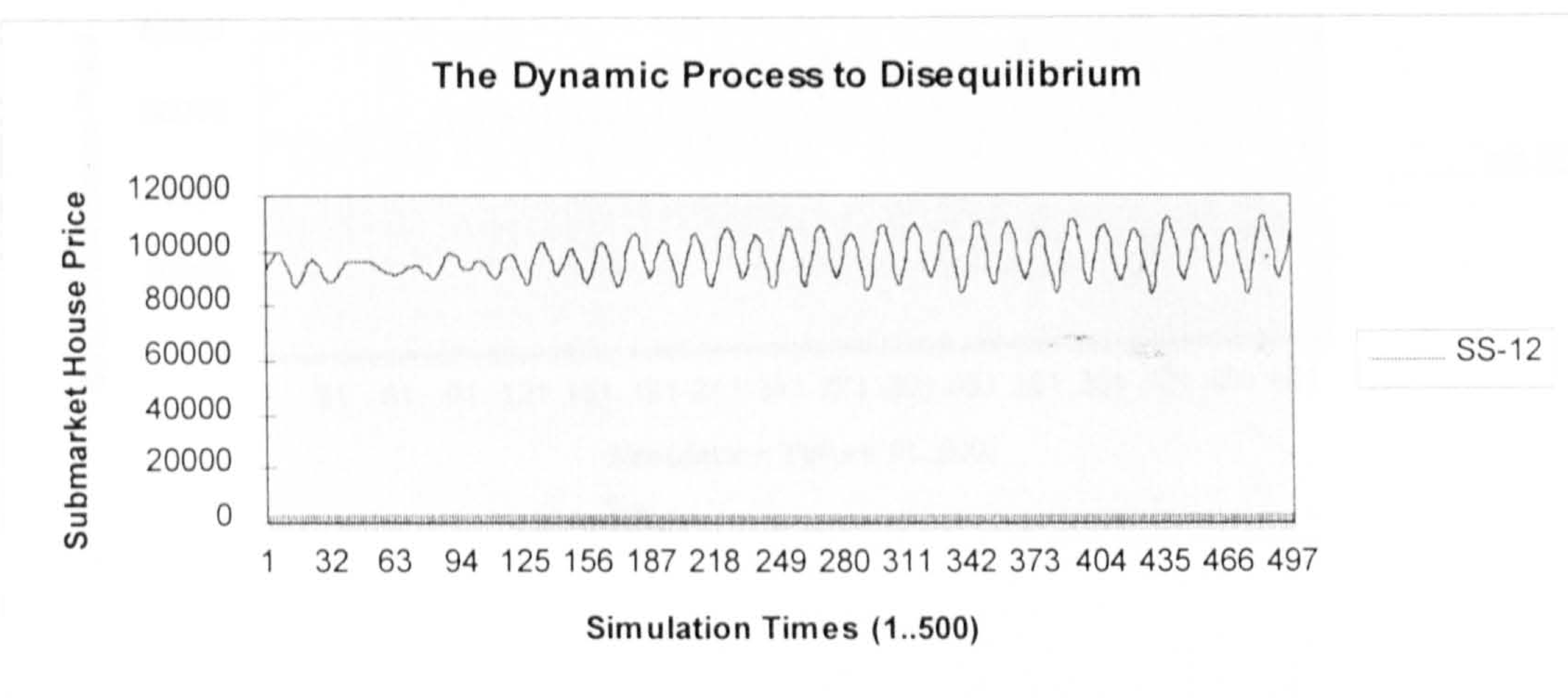


Diagram 7

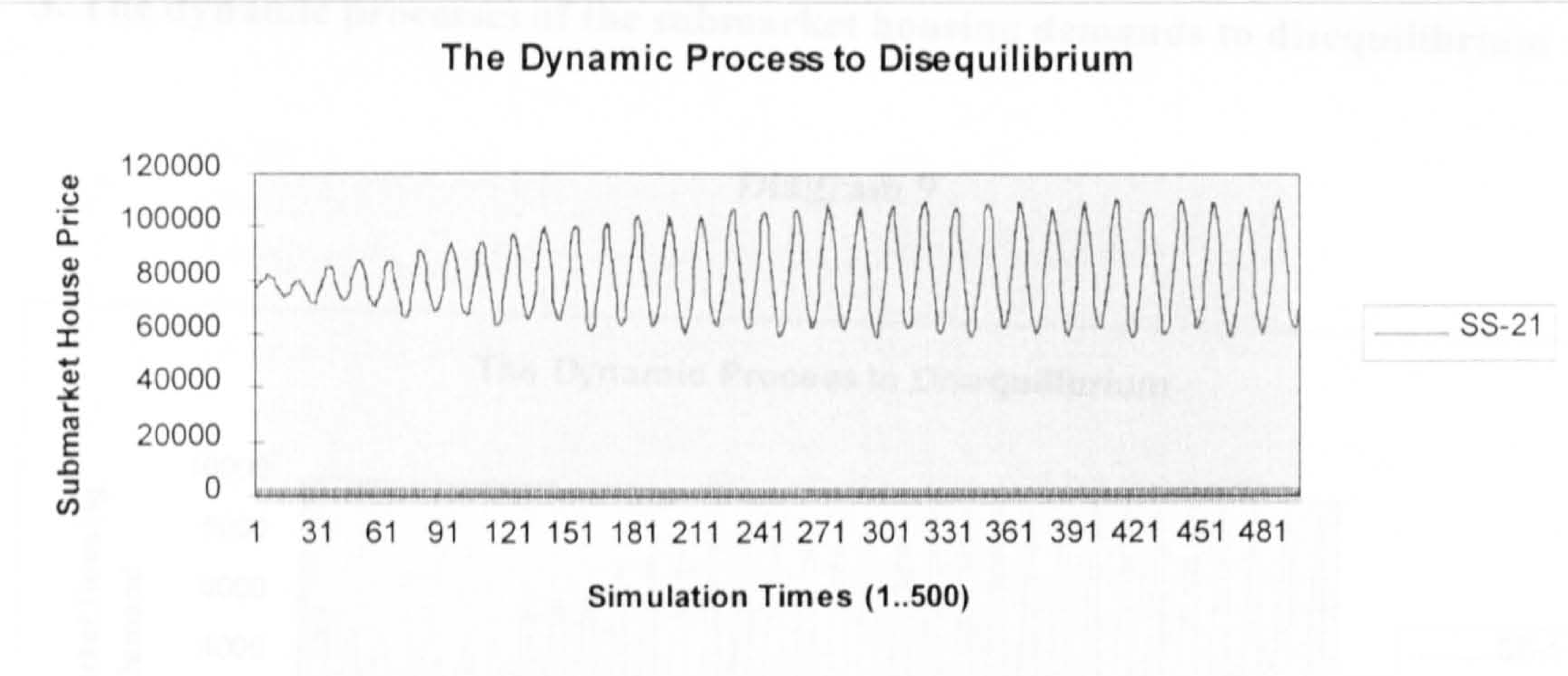
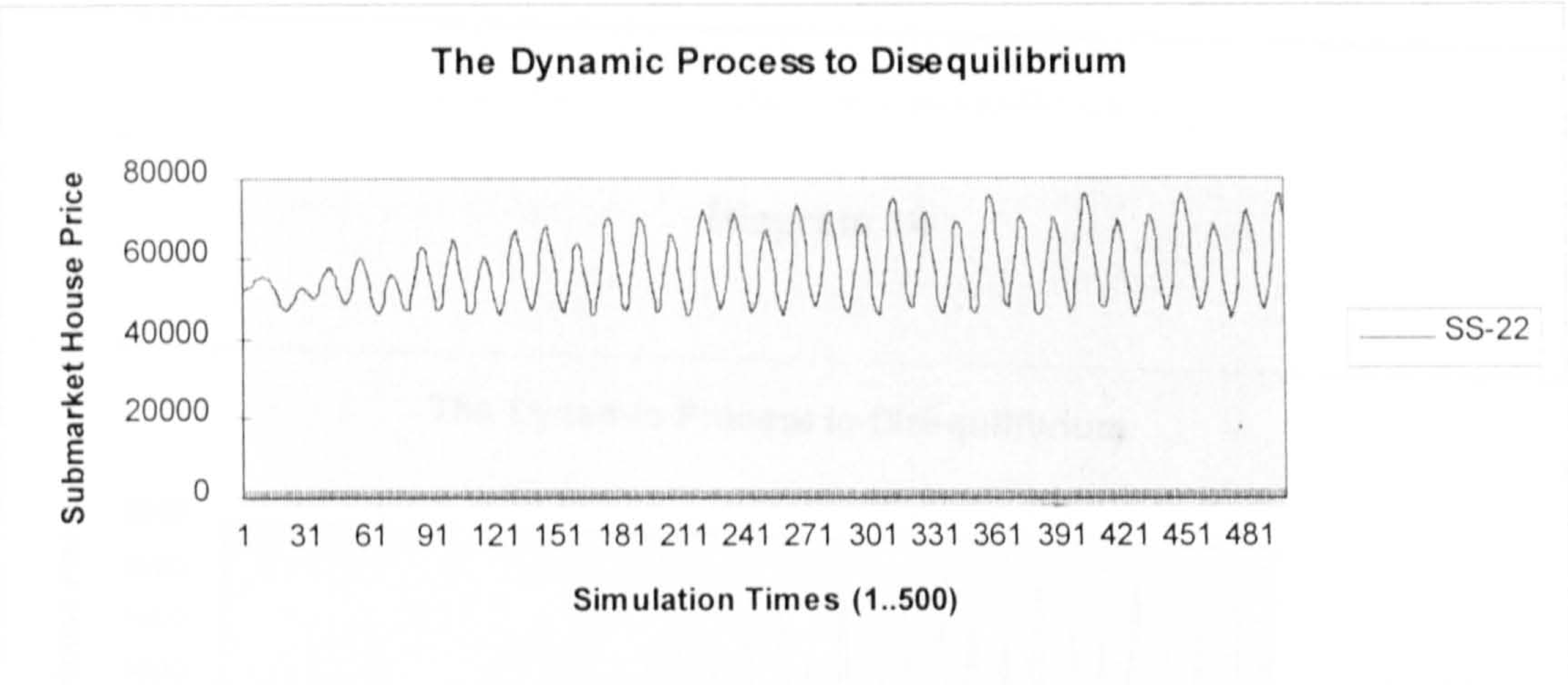


Diagram 8



3. The dynamic processes of the submarket housing demands to disequilibrium

Diagram 9

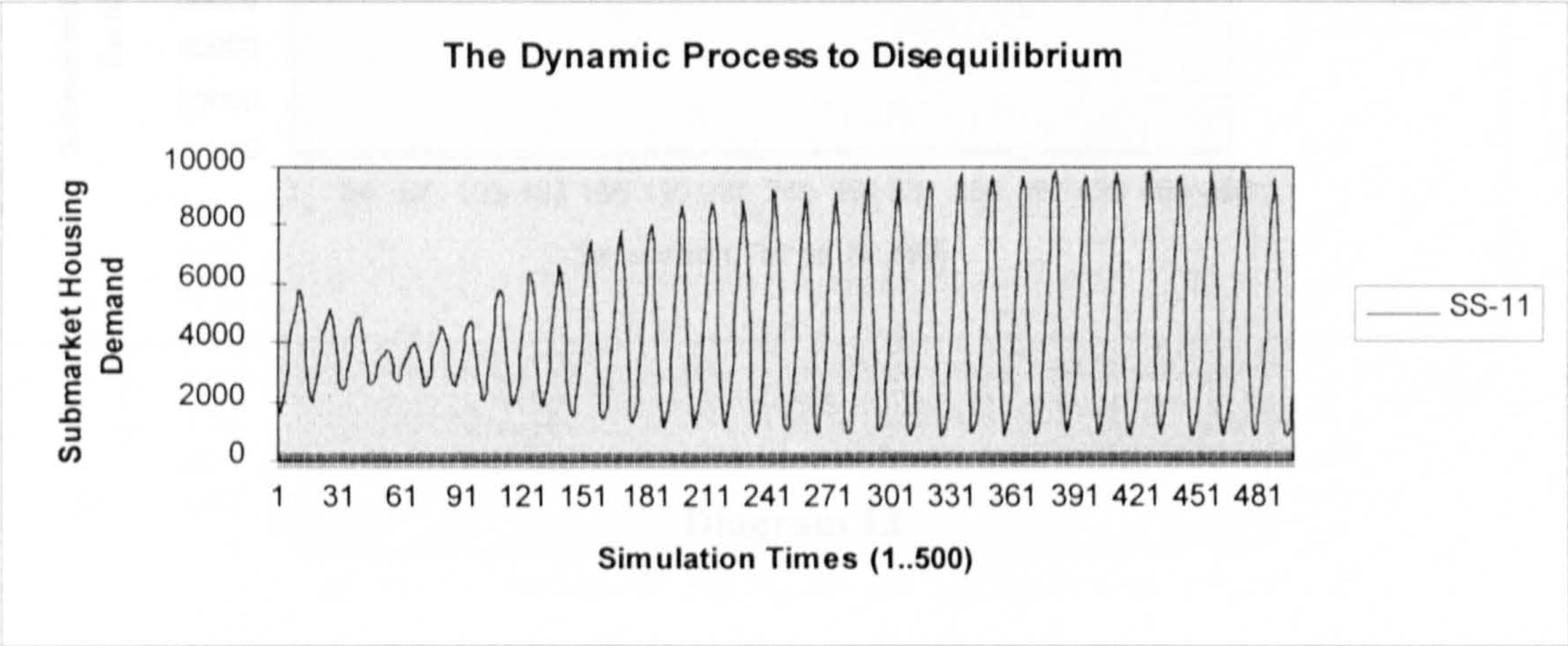


Diagram 10

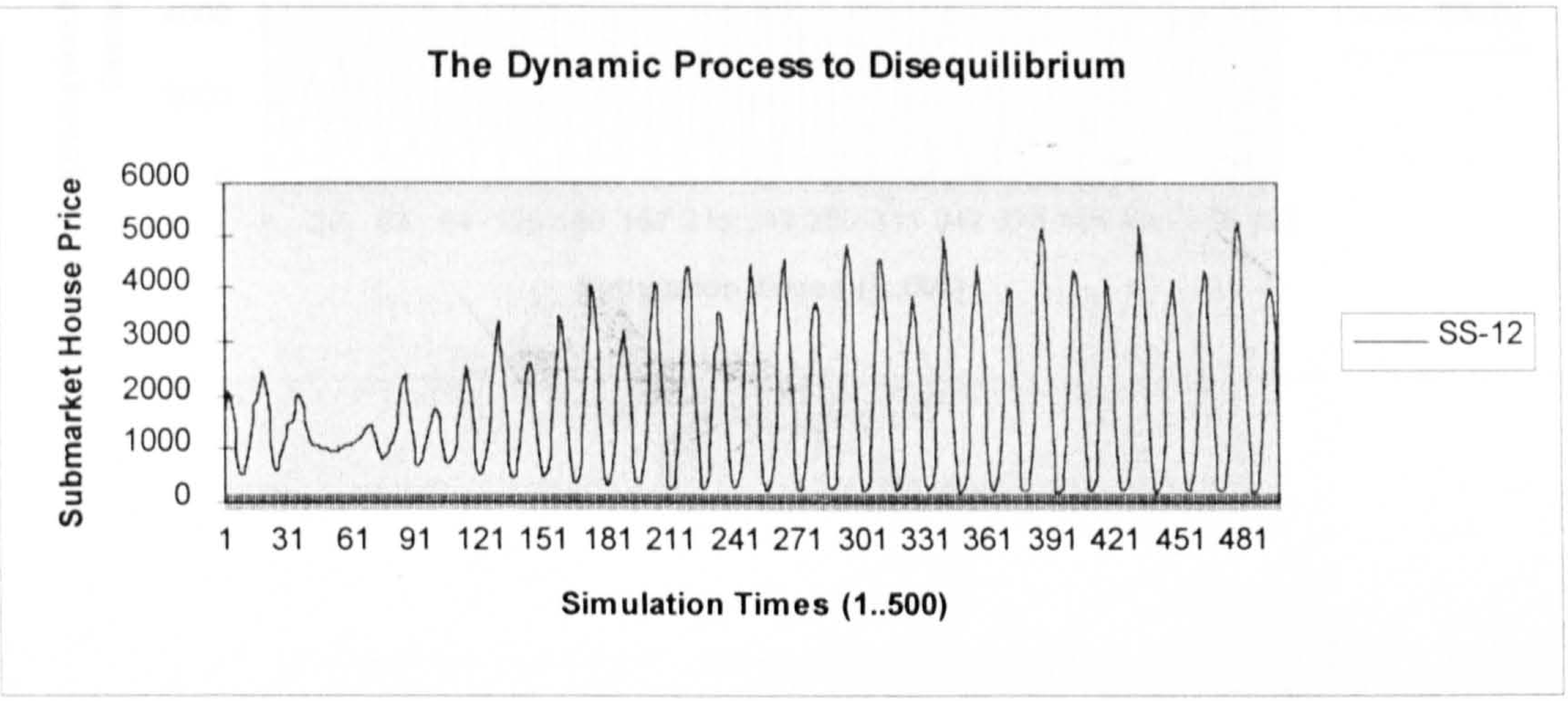


Diagram 11

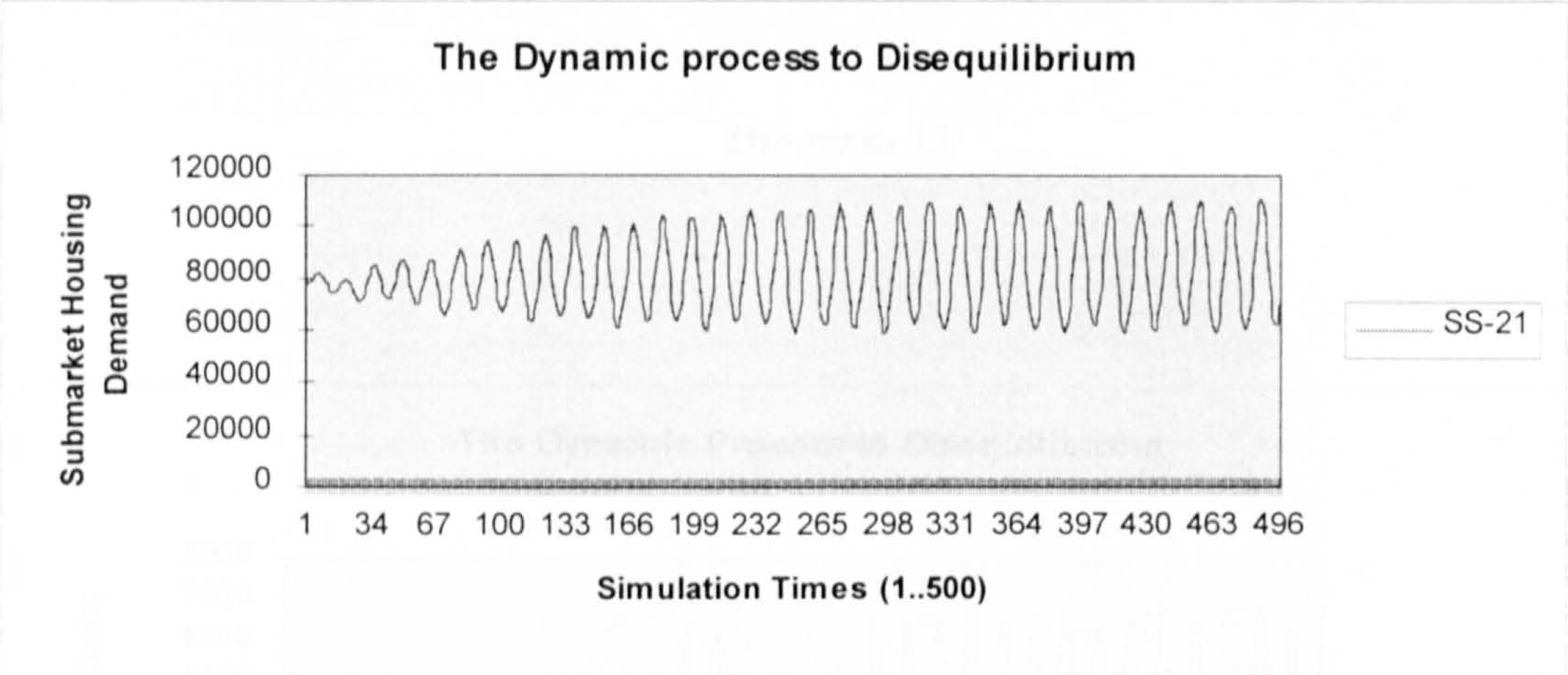
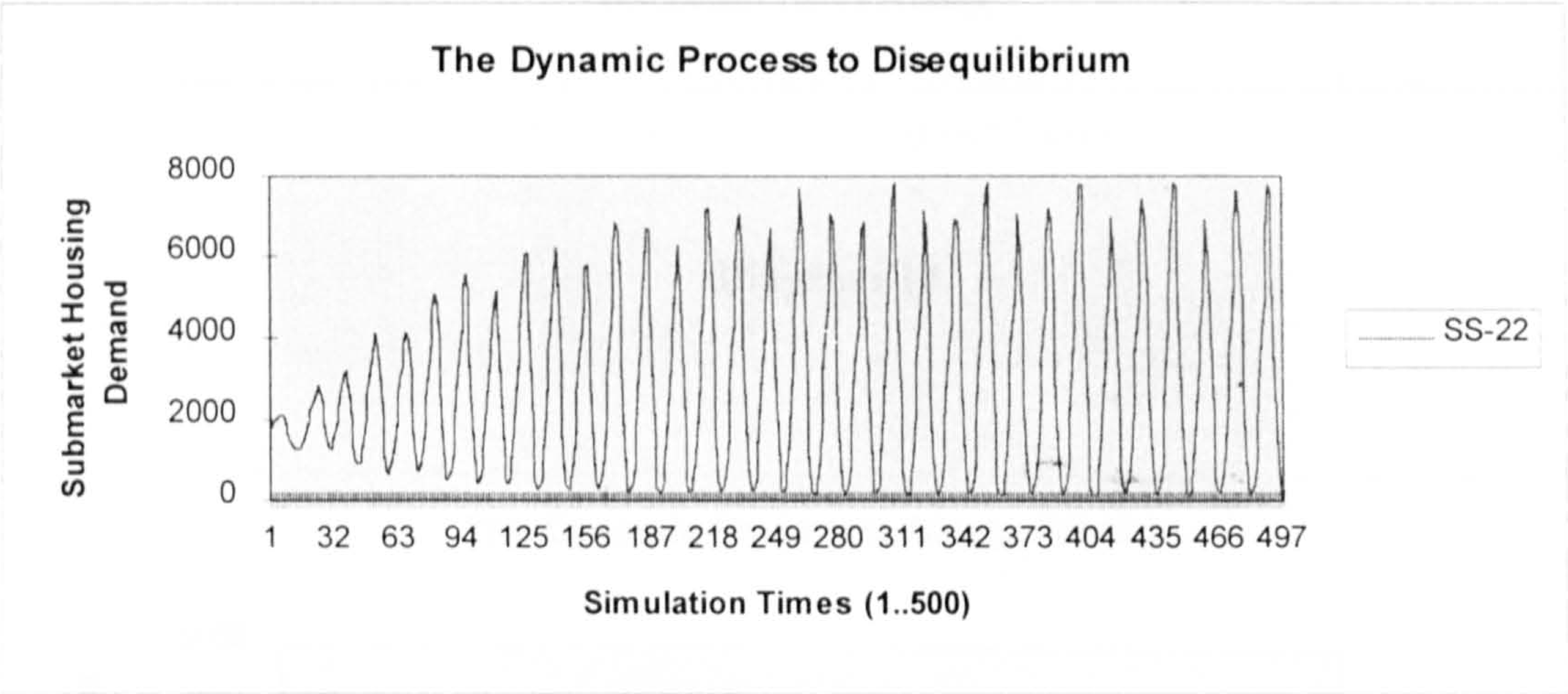


Diagram 12



4. The dynamic processes of the submarket housing supplies to disequilibrium

Diagram 13

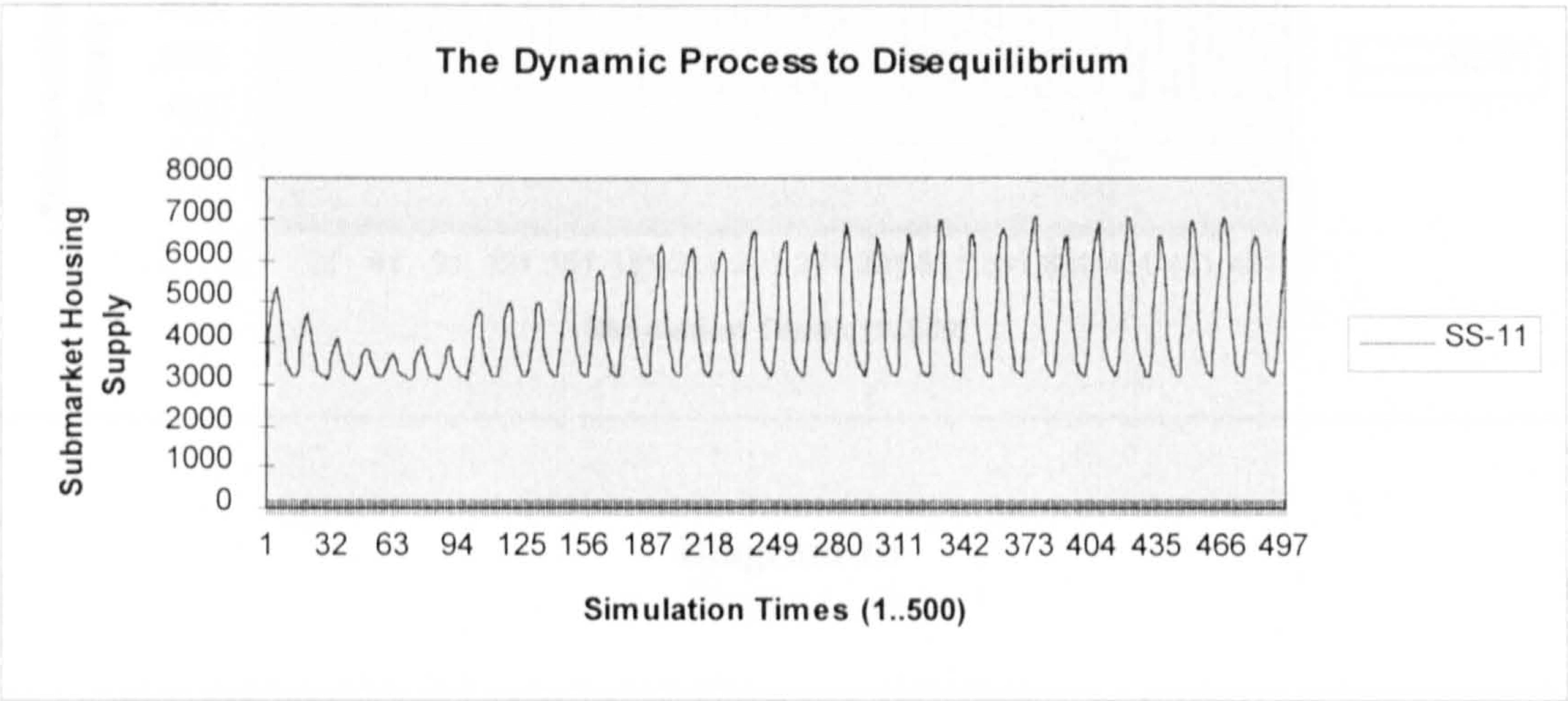


Diagram 14

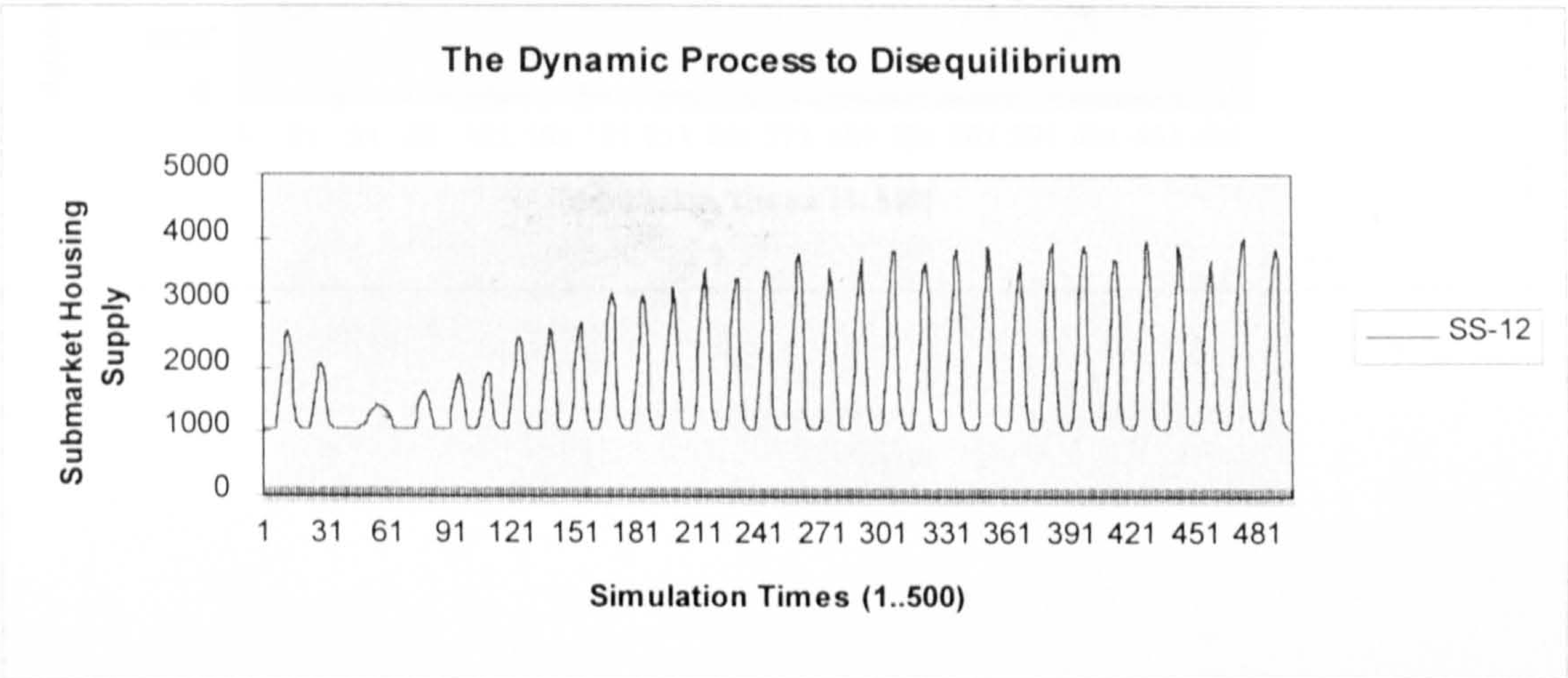


Diagram 15

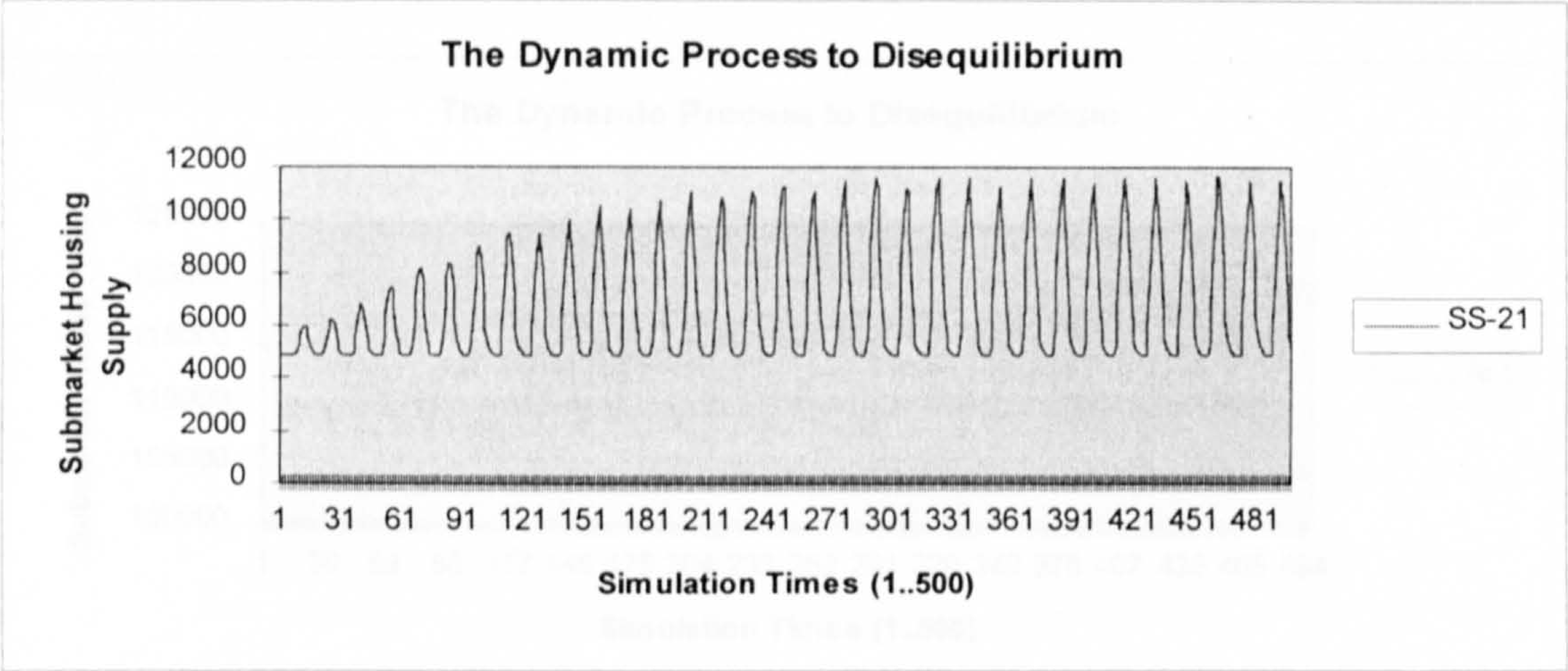
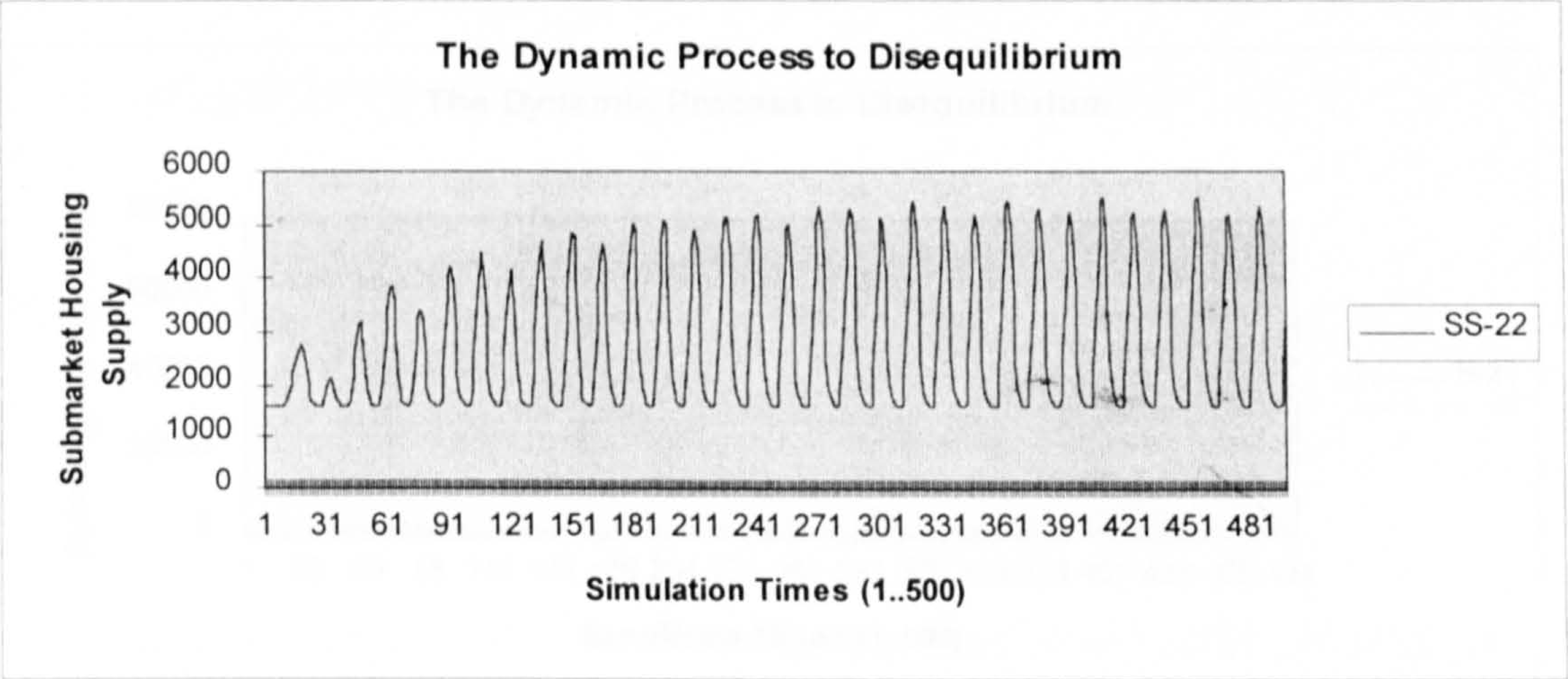


Diagram 16



5 The dynamic processes of the neighbourhood housing price to disequilibrium

Diagram 17

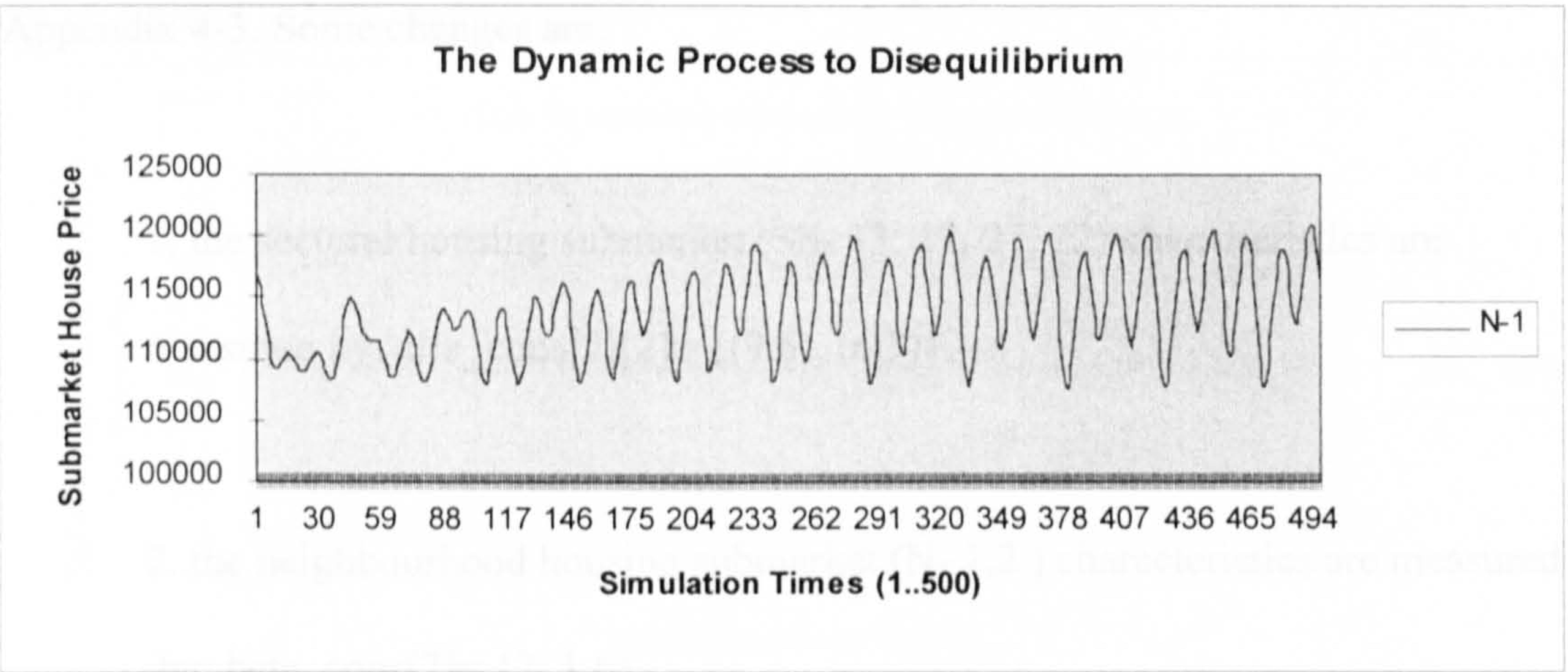
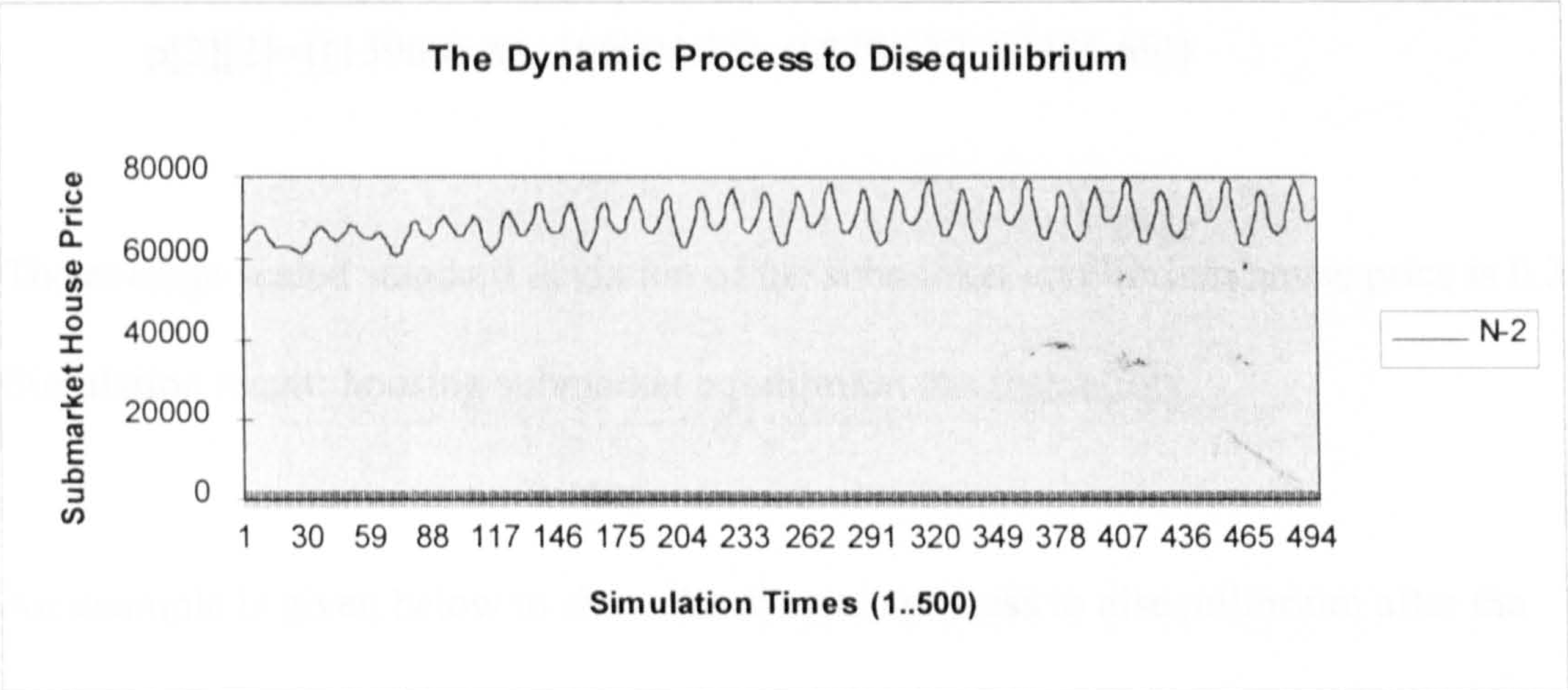


Diagram 18



Appendix 4-8
Simulation Case Three: towards disequilibrium (2)

This simulation is based on the nested housing submarket structure identified in Appendix 4-3. Some changes are:

1. the sectoral housing submarket (SS- 11, 12, 21, 22) characteristics are measured by: alfa_cons[2][2]= {(9,5), (6,3)}.

2. the neighbourhood housing submarket (N- 1,2) characteristics are measured by: beta_cons[2]= {2, 1.6}.

3. the sectoral housing submarket equilibrium house prices are: p[2][2]={(139606.86, 105004.35), (88796.32, 63435.69)}

The average scaled standard deviation of the submarket equilibrium house price is 0.32. Simulation result: housing submarket equilibrium has instablility.

An example is given below to show the dynamic process to disequilibrium after the housing price in SS-11 is increased 1% from the equilibrium price.

1. The dynamic processes of the buyers' choice probabilities for the different housing submarkets to disequilibrium

Diagram 1

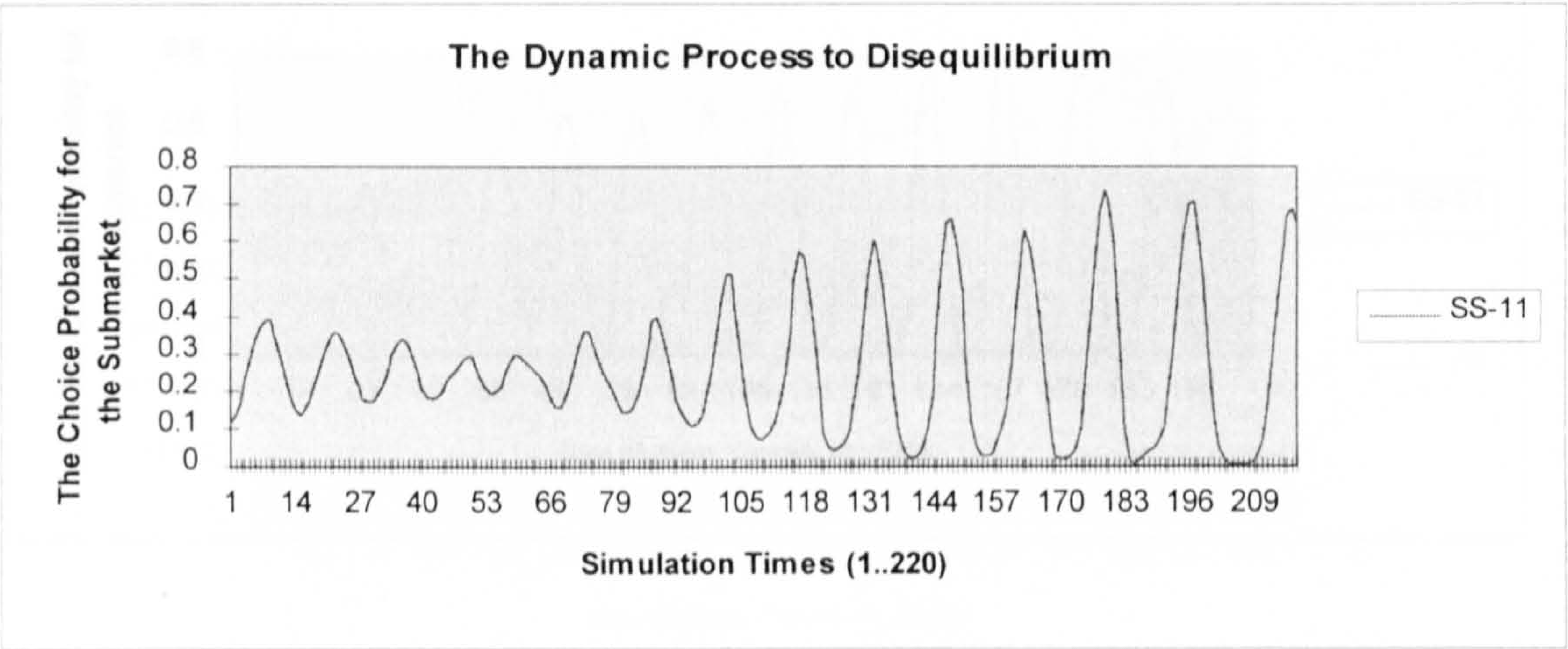


Diagram 2

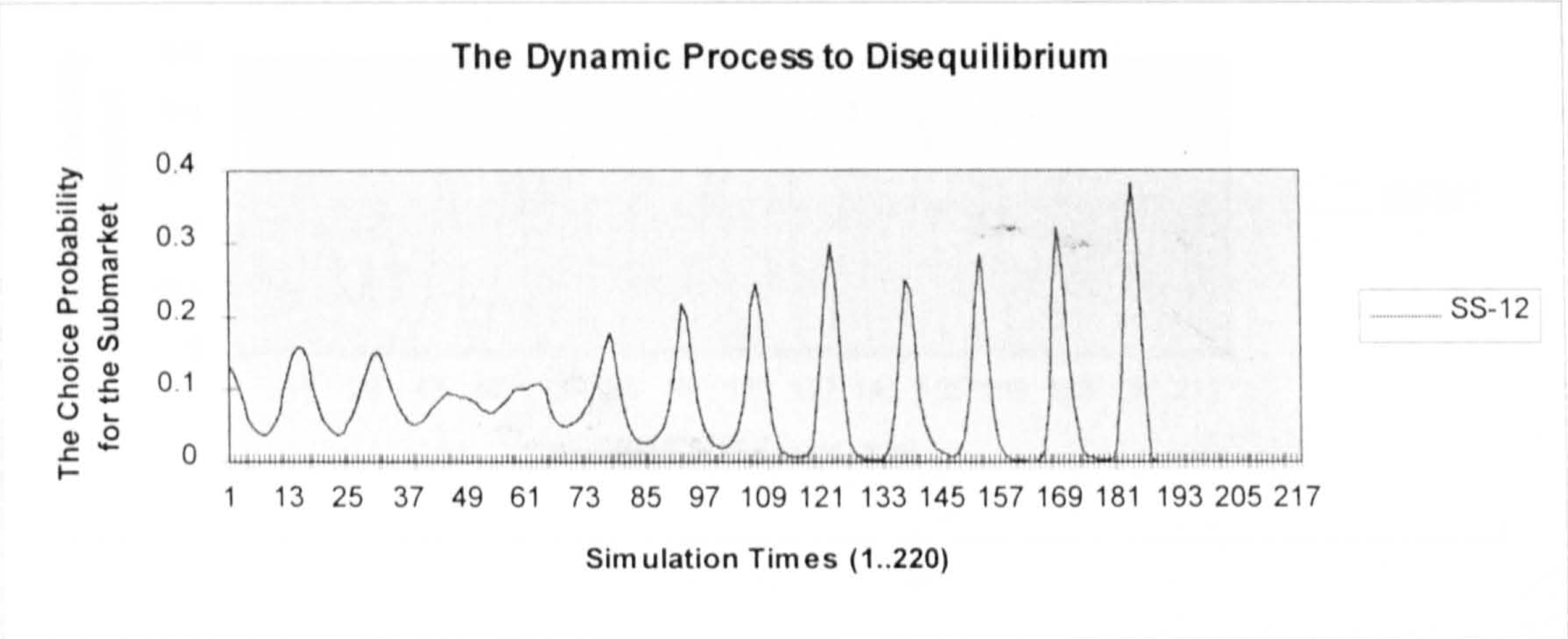


Diagram 3

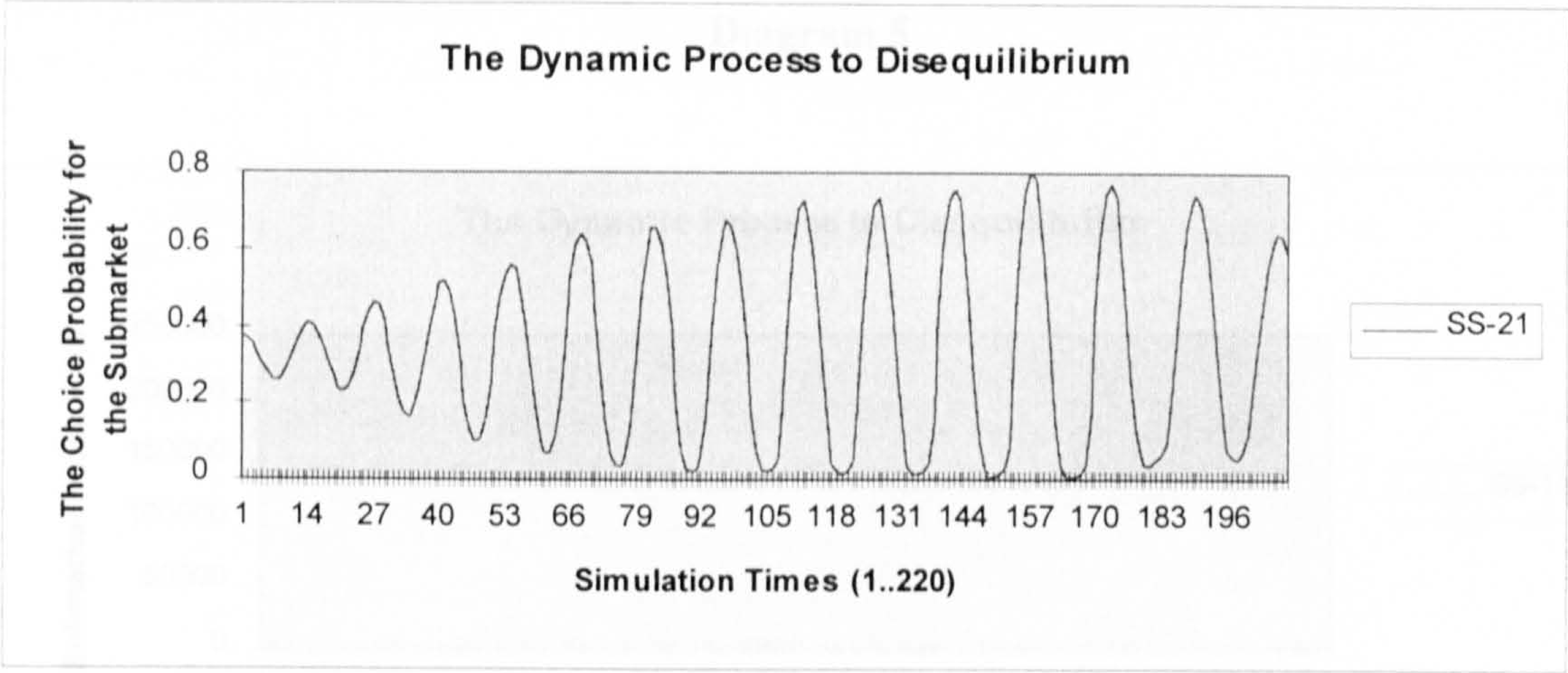
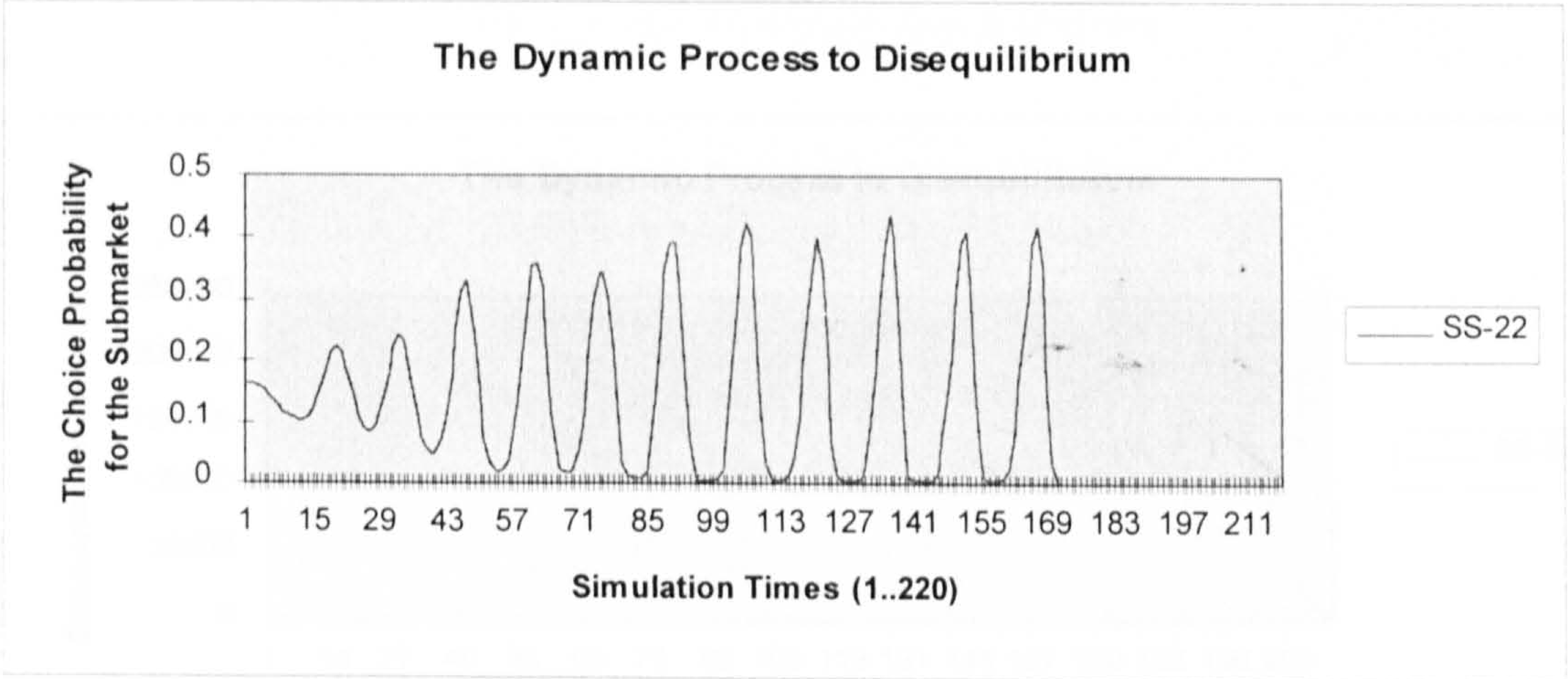


Diagram 4



2. The dynamic processes of the submarket housing prices to disequilibrium.

Diagram 5

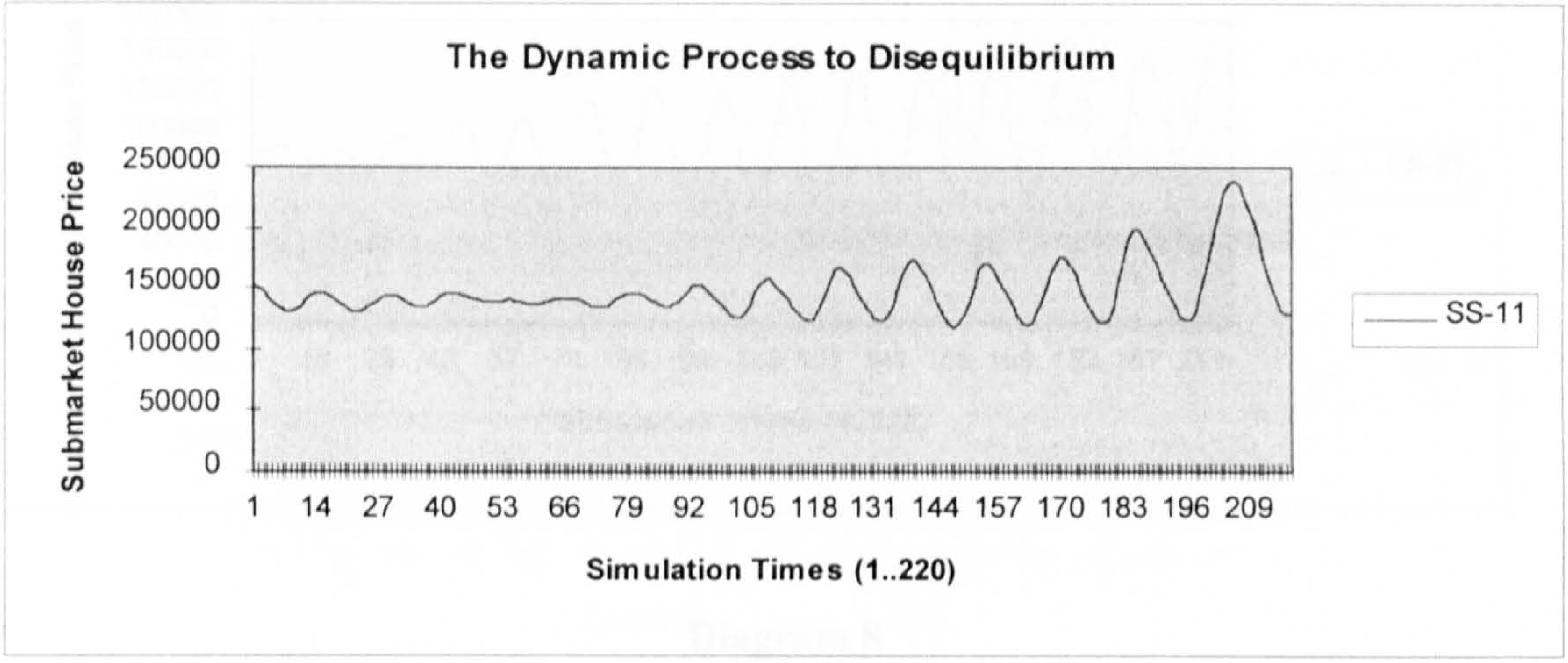


Diagram 6

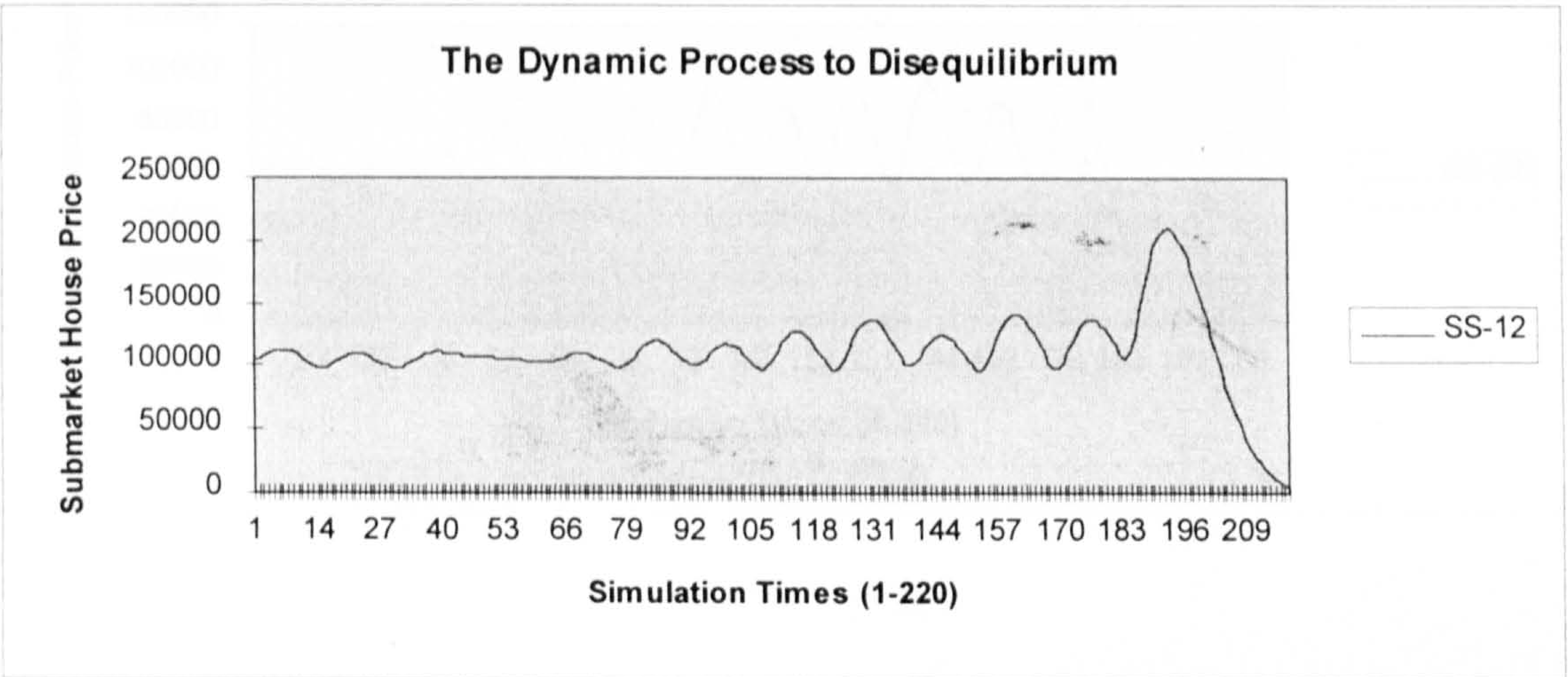


Diagram 7

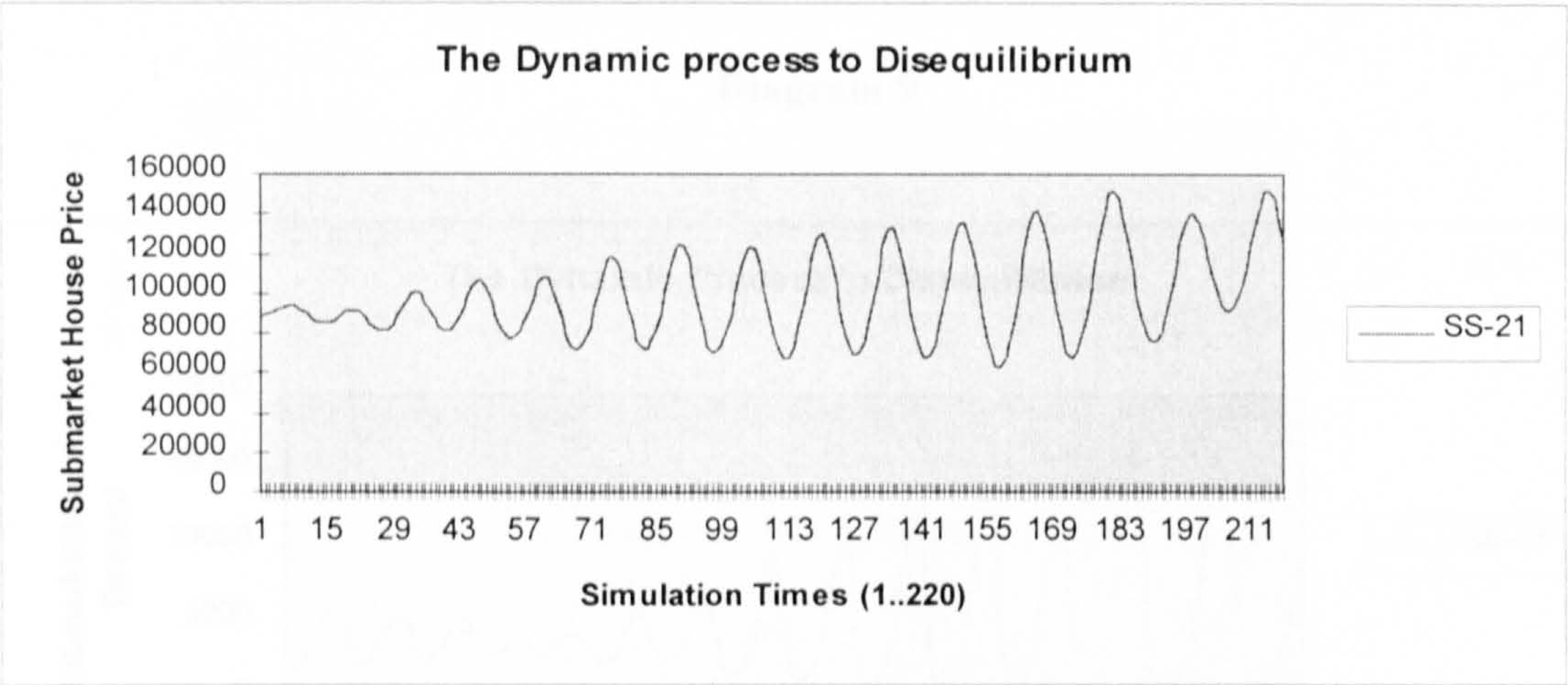
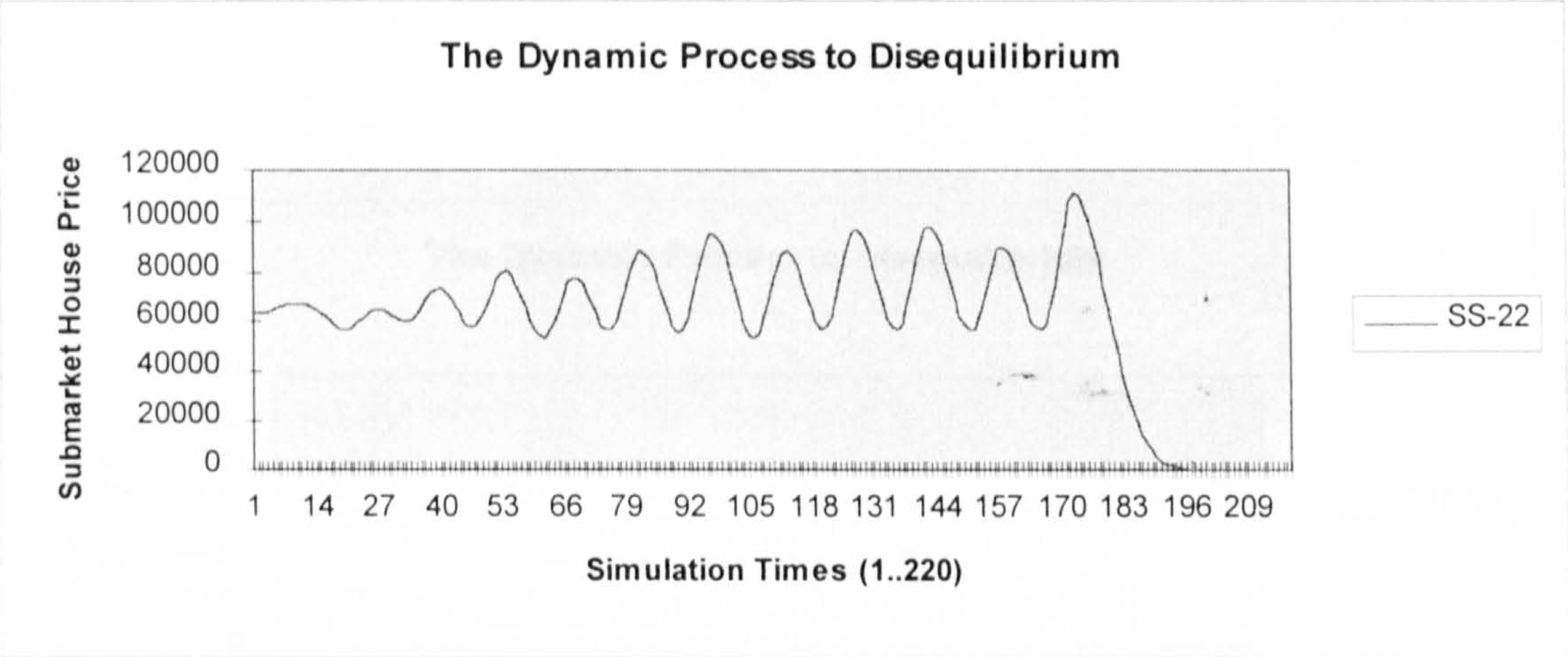


Diagram 8



3. The dynamic process of the submarket housing demands to disequilibrium

Diagram 9

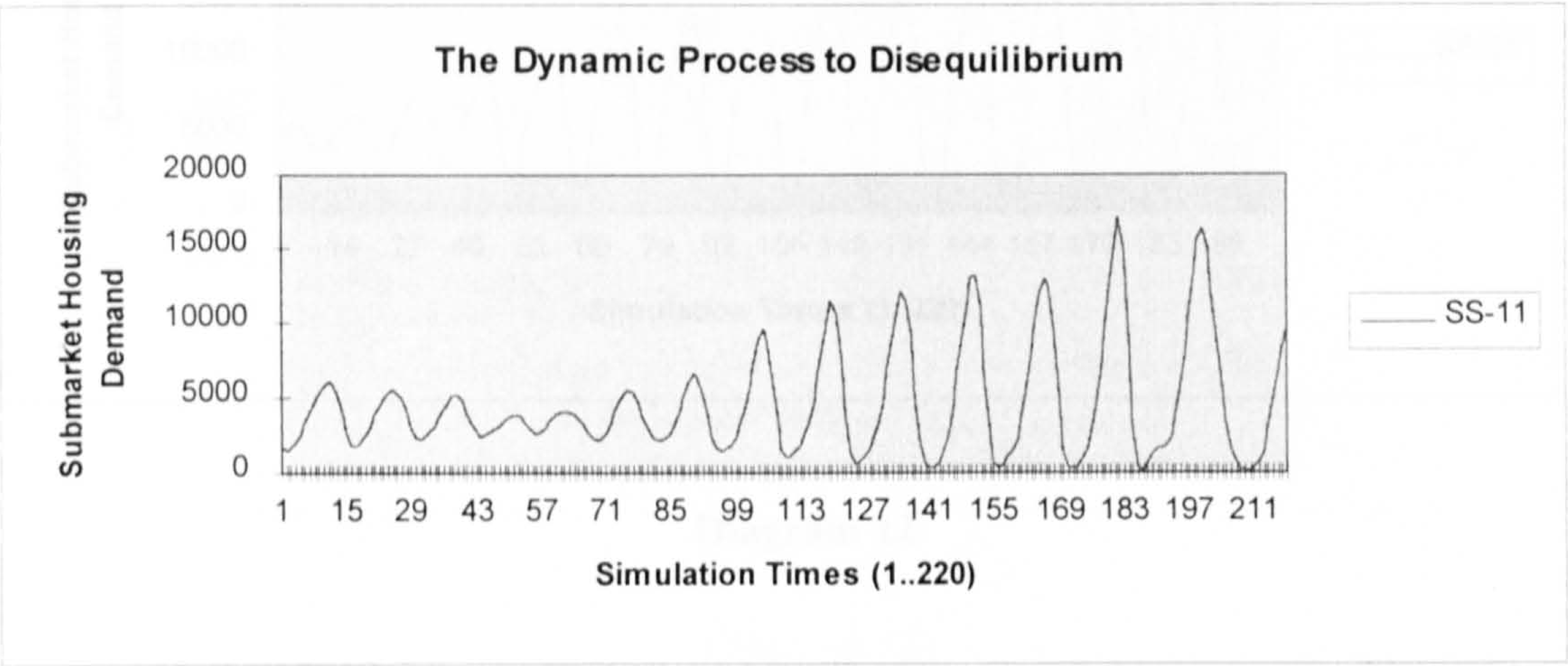


Diagram 10

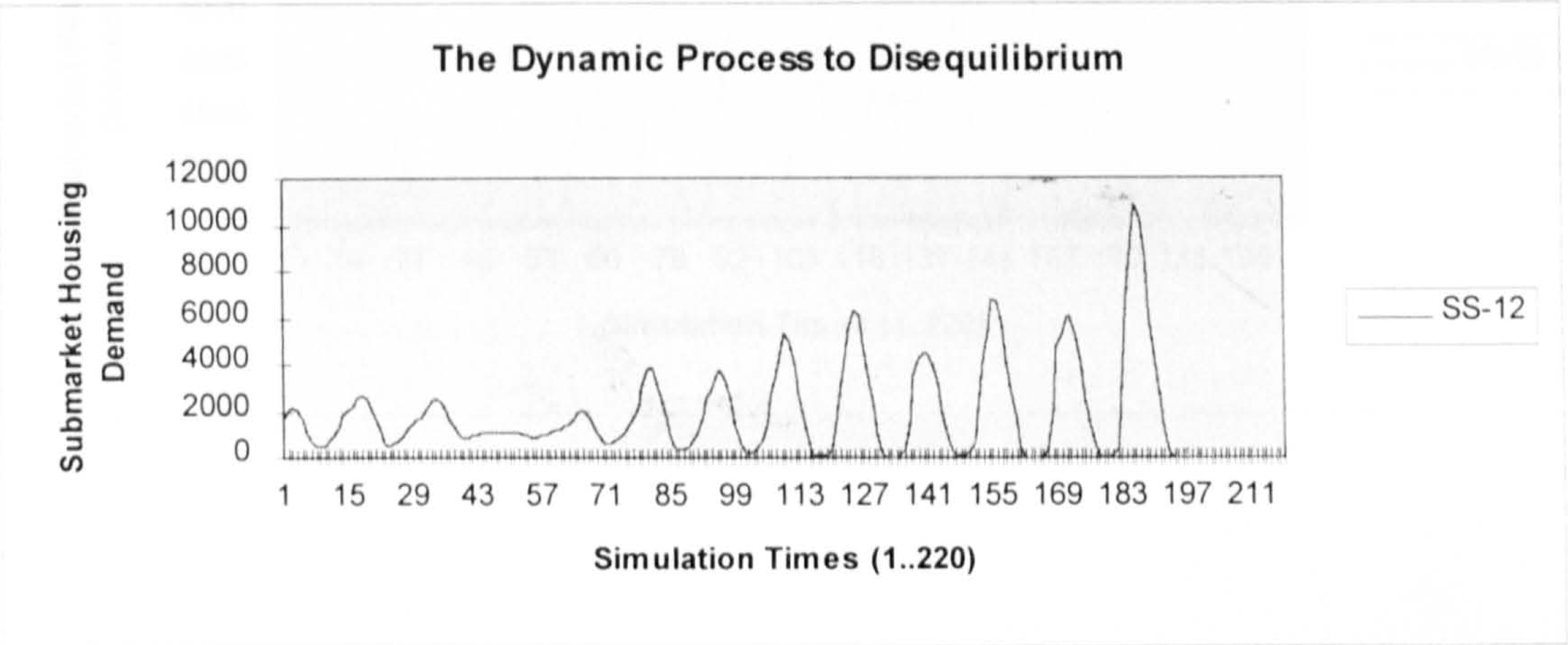


Diagram 11

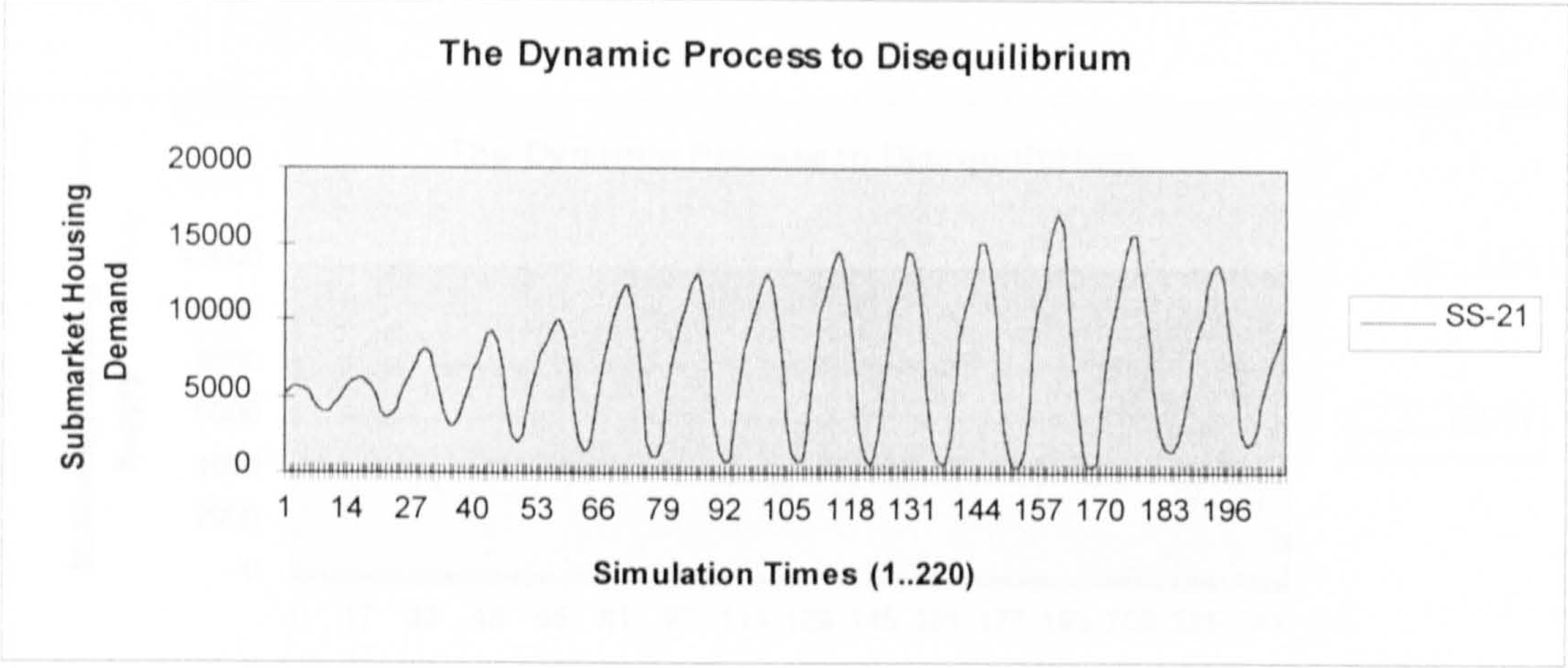
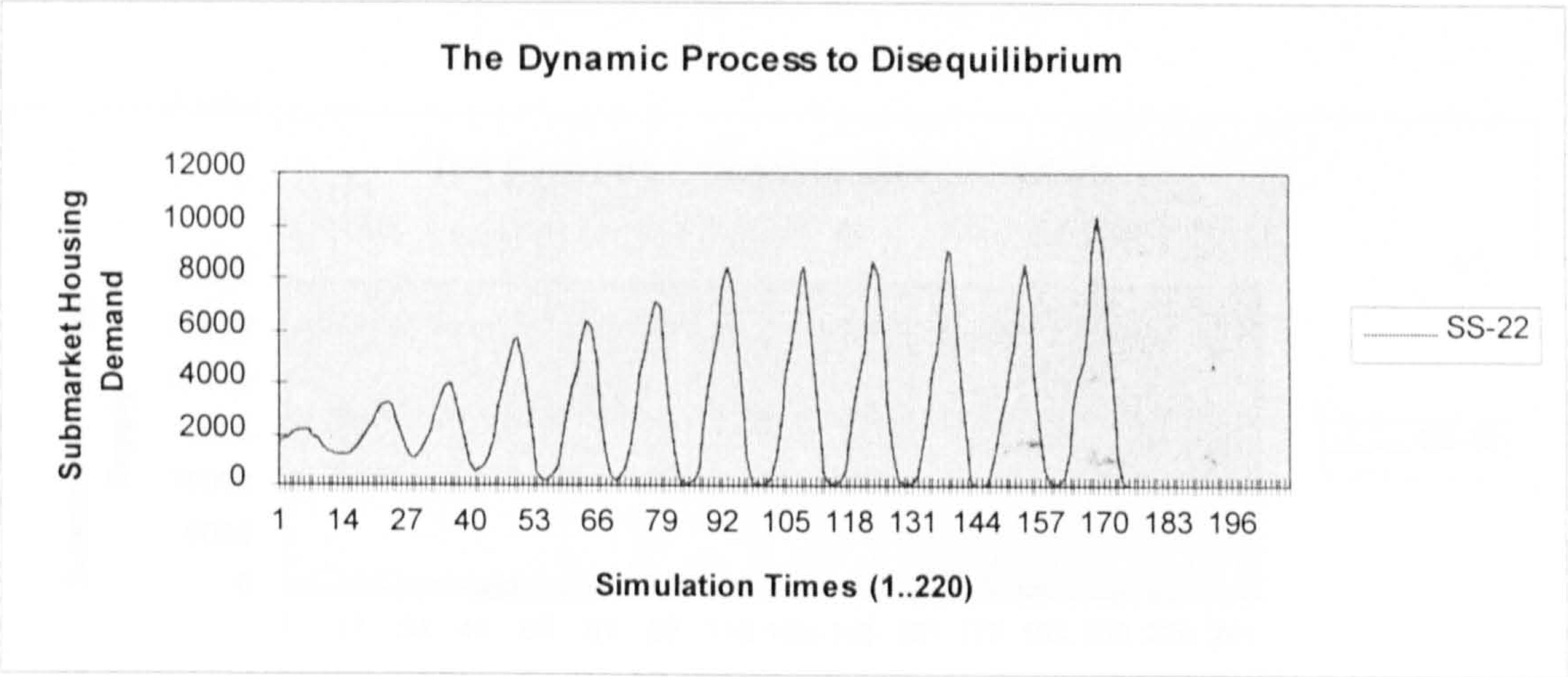


Diagram 12



4. The dynamic processes of the submarket housing supply to disequilibrium

Diagram 13

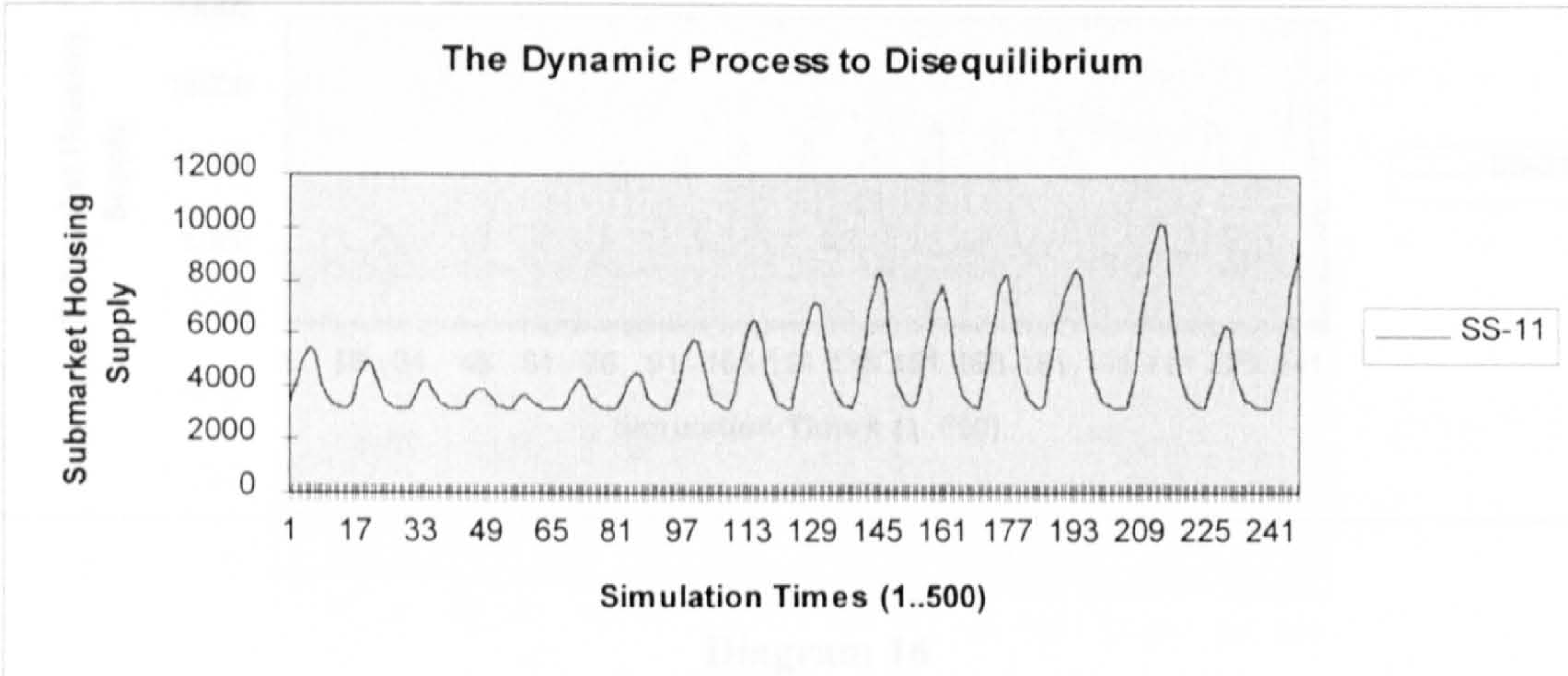


Diagram 14

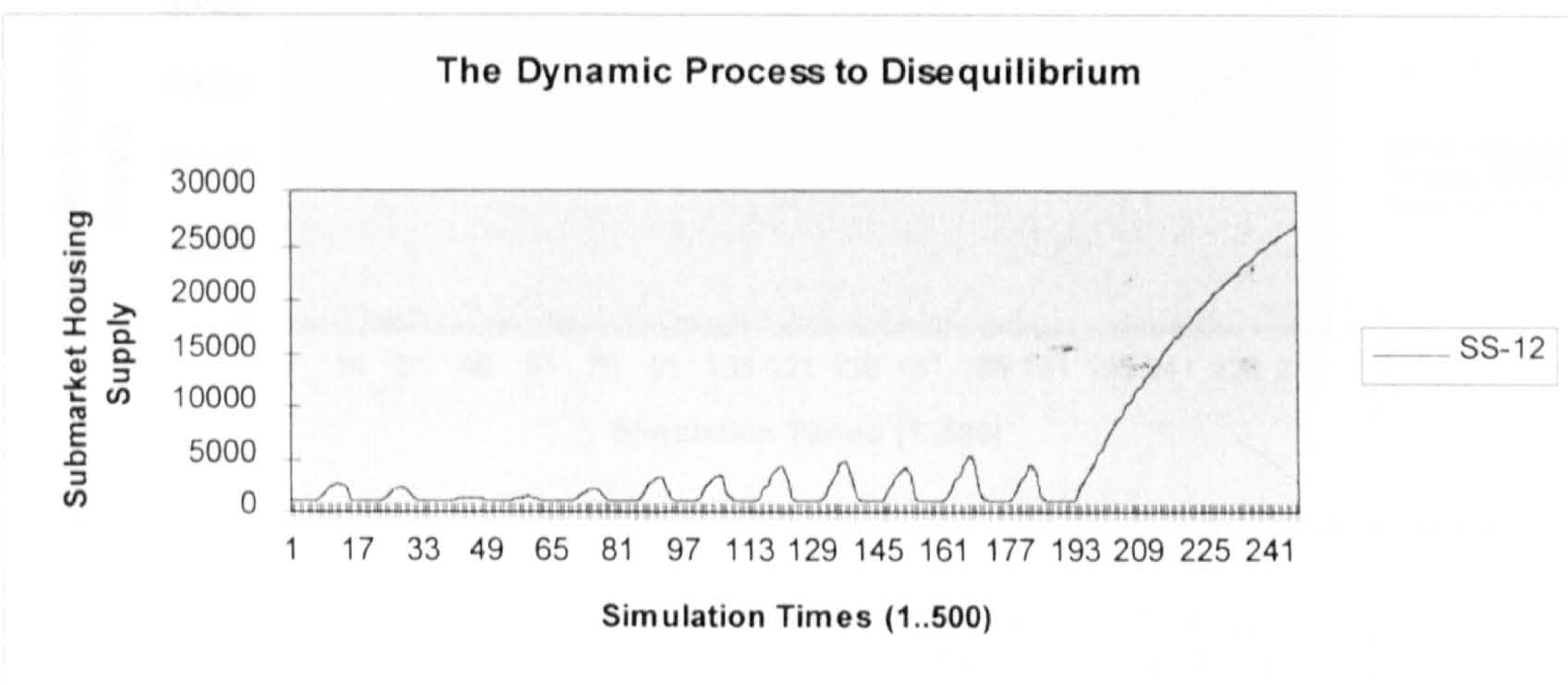


Diagram 15

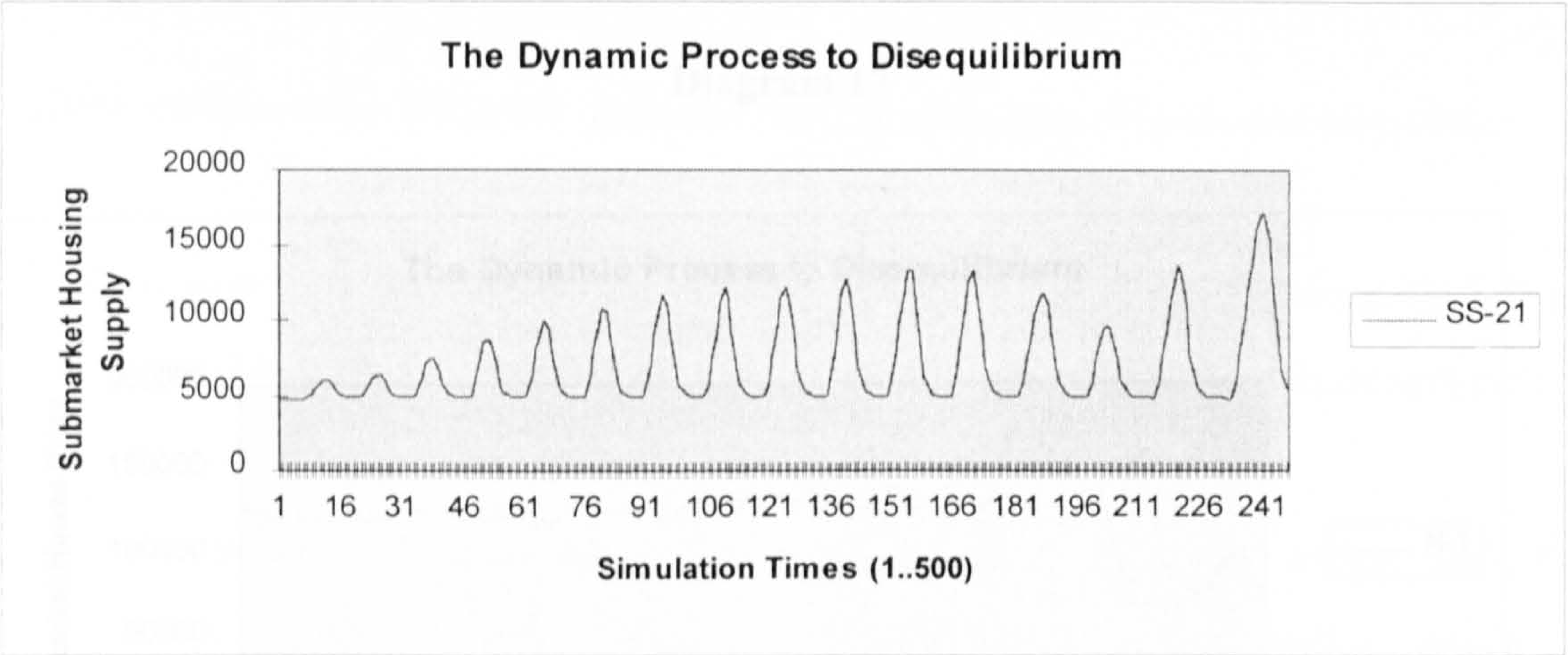
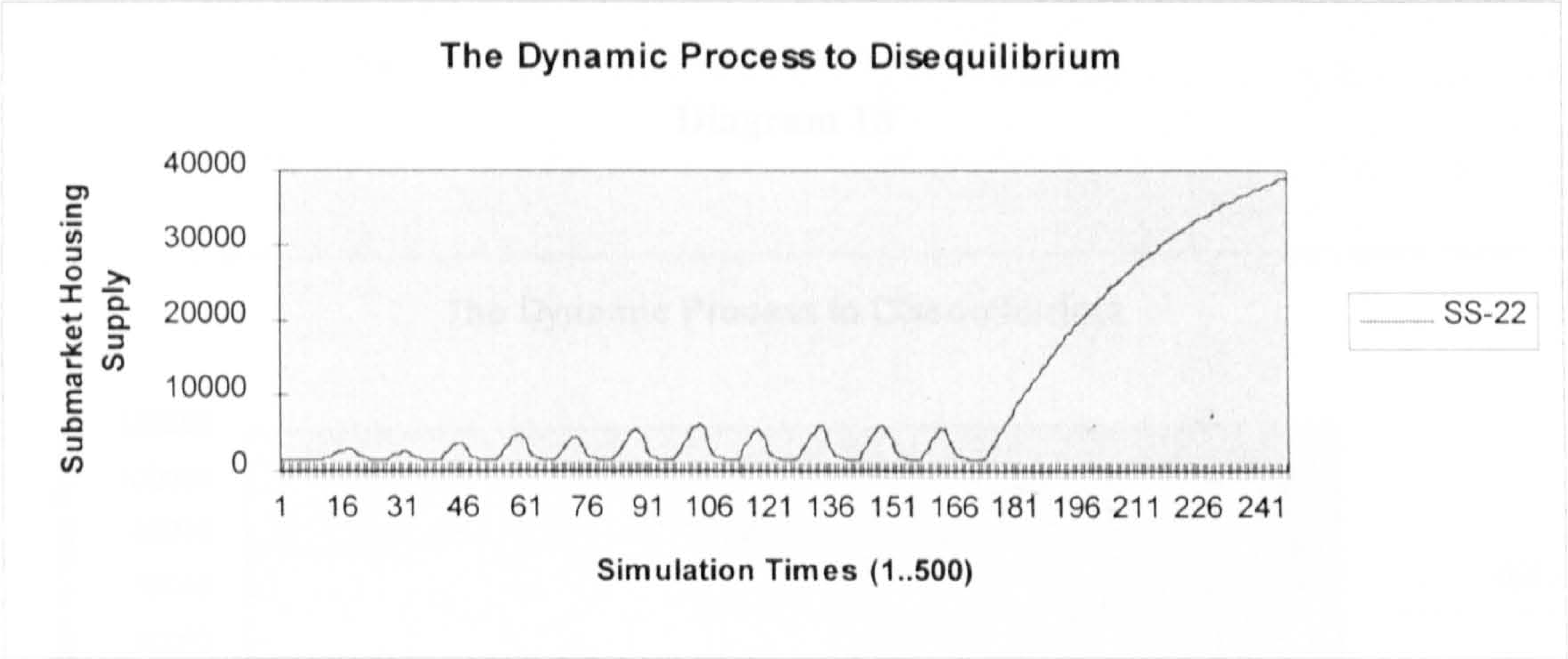


Diagram 16



5. The dynamic processes of the neighbourhood housing prices to disequilibrium

Diagram 17

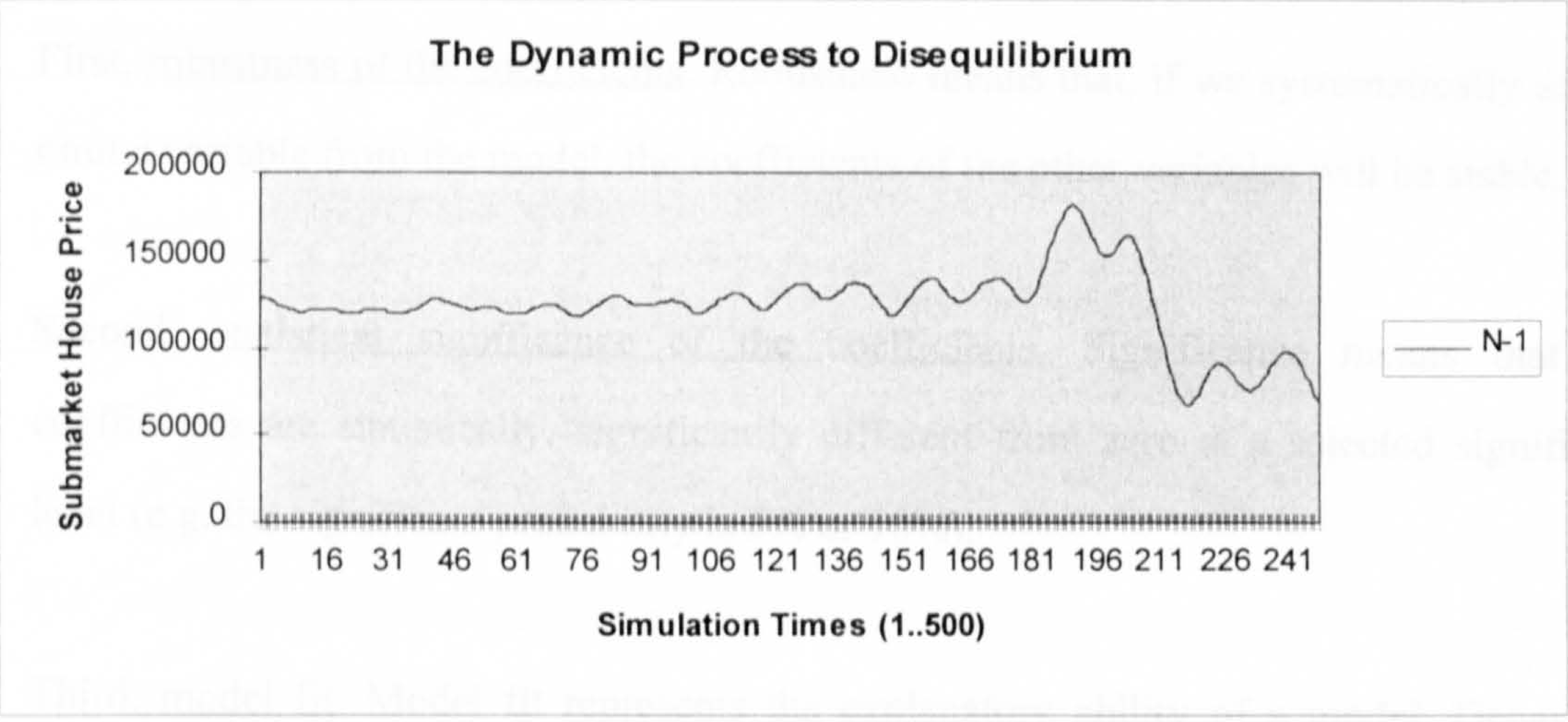
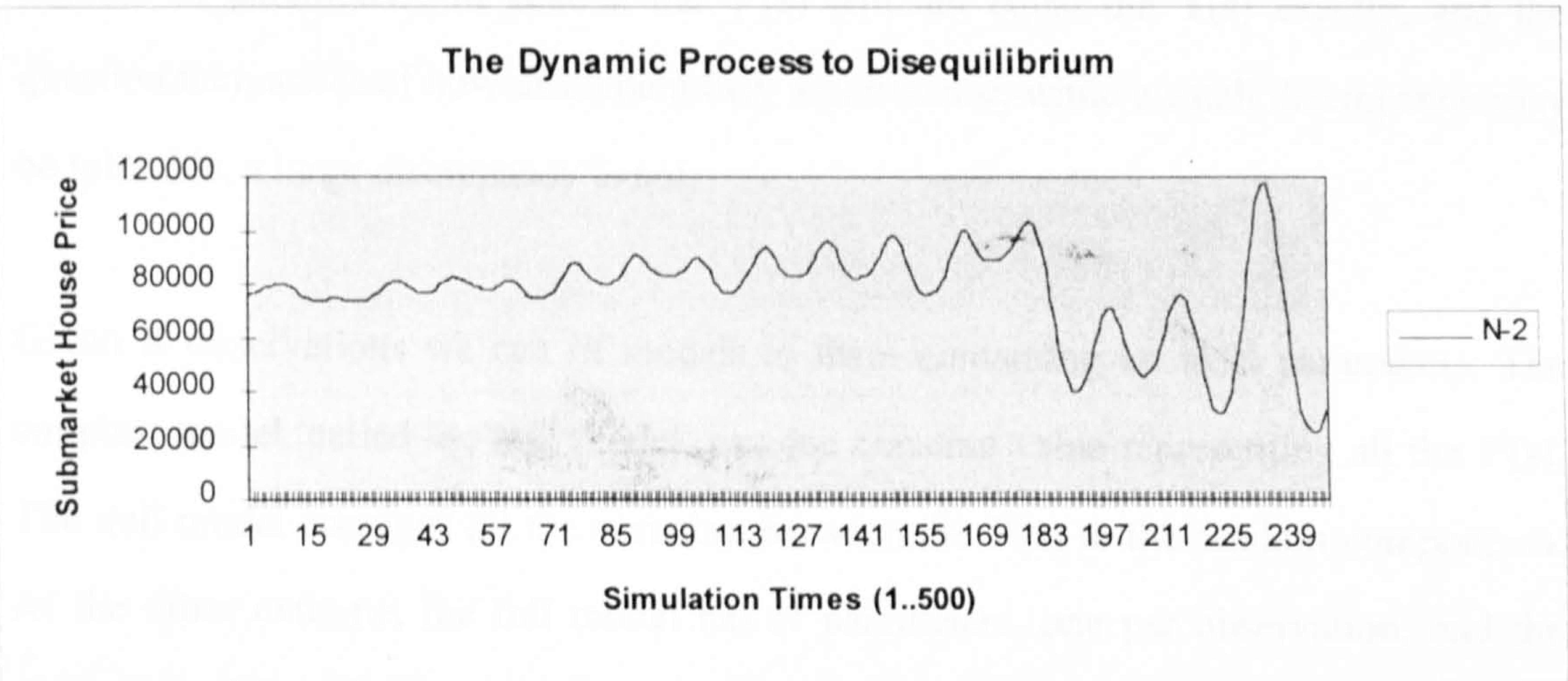


Diagram 18



Appendix 6-1
Statistical Diagnoses Used in Evaluating Discrete Choice Model

There are three main statistical diagnoses used in evaluating discrete choice model.

First, robustness of the coefficients. Robustness means that, if we systematically add or omit a variable from the model, the coefficients of the other variables will be stable.

Second, statistical significance of the coefficients. Significance means that the coefficients are statistically, significantly different from zero at a selected significant level (e.g. the significant probability is 5% or 10%).

Third, model fit. Model fit represents the explanatory ability of a model. Generally, fitting a model to data may be regarded as a way of replacing a set of data values Y(s) by a set of fitted values $\hat{Y}$(s) derived from a model involving (usually) a relatively samll number of parameters. In general the $\hat{Y}$(s) will not equal the Y(s) exactly, and the question then arises of how discrepant they are, because, while a small discrepancy may be tolerable, a large discrepancy is not.

Given N observations we can fit models to them containing up to N parameters. The simplest model, called the null model, has one constant value representing all the Y(s). The null model consigns all the variation between the Y(s) to the random components. At the other extreme, the full model has N parameters, one per observation, and the $\hat{Y}$(s) derived from it match the data exactly. The full model consigns all the variation in the Y(s) to the systematic components leaving none for the random components. However, in reality, the full model is too ideal and unavailable.

In discrete choice models (e.g. the MNL, or the NMNL models), the comparison between the observed and the predicted values is based on the concept of the Log-Likelihood. The definition and calculation of Likelihood are given in Hosmer 1989.

The Restricted Likelihood (L_0) is calculated from the Null model with no parameters, and represents the discrepancy of the observations (dependent variables). The restricted log-likelihood (l_0) is:

$$l_0 = \log(L_0) \qquad (1)$$

The likelihood (L_β)of a logistic function (e.g. the NMNL model or the MNL model) is calculated from a model which includes some parameters. The log-likelihood is:

$$l_\beta = \log(L_\beta) \qquad (2)$$

The difference between l_0 and l_β represents the explanatory ability of those parameters.

For a given group of observations, this difference is defined as

$$\chi^2 = -2(l_0 - l_\beta) \qquad (3)$$

which follows χ^2 distribution.

The larger χ^2 is , the higher the explanatory ability of the model will be. However, the value of χ^2 will automatically increase as the sample size increases. This creates difficulties in model comparison if the models are calibrated based on different sample sizes.

Another statistical diagnosis, which is called Pseudo-R^2, is developed for evaluating model fit by likelihood. The definition is given by Equations (4) to (5).

$$Pseudo-R^2 = \frac{R^2}{\max(R^2)} \tag{4}$$

$$R^2 = 1-\left(\frac{L_0}{L_\beta}\right)^{\frac{2}{n}} \text{ and } \max(R^2) = 1-\left(L_0\right)^{\frac{2}{n}} \tag{5}$$

$$0 \le Pseudo-R^2 \le 1 \tag{6}$$

From the definition, we can find that larger $Pseudo-R^2$ represents a higher explanatory ability. For example, $Pseudo-R^2$=0.6 means that the model can explain 60% of the data Y(s). As the influence of the sample size n is diminishing from $Pseudo-R^2$, this statistical diagnosis provides a common basis to compare the model fit.

Appendix 6-2
Questionnaire

The structure of this questionnaire includes three sections.

The first section of the questionnaire is designed to obtain the personal information of the head of a household. A household is defined as a group of people who are living in the same dwelling, sharing facilities and having a meal together at least once a day and/or a single person living alone. The decision of whether or not to buy a dwelling is made under the full consideration of the whole household. Although the whole household is treated as one unit when buying a house, the function of the head of a household is very important. The head of a household is defined as the person or group of people in a household who is/are the main bread-winner(s) for the household. According to this definition, each household can have more than one person as the head.

The definitions of the household and the head of a household were provided to the respondents in the covering letter. From the survey result, only 1% of the households were unhappy with this definition and claimed that they didn't have a single head of the household.

The second section of the questionnaire is designed to obtain information on the dwelling and the household as a whole.

The information on dwelling choice includes:1. the key dwelling components (revealed preference information), 2. the non-key dwelling components (both revealed and stated preference information).

The first group of information is used to calibrate a buyer's choice behaviour for a submarket. In particular, the physical neighbourhood condition is obtained from the respondent's personal judgement about his/her neighbourhood.

The second group of the information is used to record the buyer's choice behaviour for those non-key components. The respondents were asked to rank their stated (desired) preferences for the non-key dwelling components and the calibration is based on both real choice and the desired choice to increase the predictive ability.

In order to help the respondents answer the income question, the income was classified into nine groups.

The third section of the questionnaire is designed to obtain some supplementary information on housing choice. This information is stated preference information and will be used to explain housing choice behaviour in Chapter VII

Housing Demand Survey Questionnaire

Section I The following questions refer to the *HEAD* of household. If you have two or more heads of household, please give the details for any one .

(Please tick *BOXES* where appropriate)

1. **Sex:** ☐ M ☐ F

2. **Marital Status:**
   - ☐ Married/living with long-term partner
   - ☐ Single
   - ☐ Widow/Widower
   - ☐ Divorced/Separated

3. **Age:** ☐ Under 25 ☐ 25-29 ☐ 30-44
   ☐ 45-59 ☐ 60-65 ☐ over 65

4. **Is the household head currently**
   - ☐ full-time employed ☐ part-time employed
   - ☐ self-employed ☐ unemployed
   - ☐ retired

5. **If full/part-time employed or self-employed:**

   - **which of the followings best describes his/her job ?**
     - ☐ managerial/supervisory
     - ☐ professional person
     - ☐ skilled worker
     - ☐ semi-skilled worker
     - ☐ other,please state ____________________

   - **in which Town or City is the job located?** ______________

   - **how does he/she get to work (<u>MAIN FORM OF TRANSPORT</u>):**

     ☐ car/van ☐ train ☐ bus ☐ walk/bike

   - **how long does he/she <u>USUALLY</u> take to get to work:**

     ☐ under 30 min. ☐ between 30-60 min.
     ☐ between 60-90 min. ☐ over 90 min.

Please turn to the next page

6. **Highest educational qualifications to date: (for the head)**

- ☐ Degree or similar academic qualification
- ☐ Professional qualification
- ☐ 'A'Levels or Highers
- ☐ 'O' Levels or 'O' Grade
- ☐ No educational qualifications.
- ☐ Other, please state________________________

Section II The following questions refer to *YOUR HOUSEHOLD AS A WHOLE.* Please give the details.

1. **In which of the following categories does your**

<u>HOUSEHOLD TOTAL ANNUAL INCOME</u>(£) fall (Before income tax)?

10,000 or less ☐	10,000-15,000 ☐	15,000-20,000 ☐
20,000-25,000 ☐	25,000-30,000 ☐	30,000-35,000 ☐
35,000-40,000 ☐	40,000-50,000 ☐	over 50,000 ☐

2. **Please give a description of the members who presently live in your home: (don't forget to include yourself, please)**

Box 1

Number of adults (aged 25 or over)	
Number of young people (aged 16-25)	
Number of young people (aged under 16)	

Box 2

Number of people in full-time employment	
Number of people in part-time employment	

3. **Before you bought your present dwelling, where did you live?**

- ☐ outside Lothian Region
- ☐ a shared dwelling with friends or relatives in Lothian Region
- ☐ your own dwelling in Lothian Region
- ☐ a privately rented dwelling in Lothian Region
- ☐ a council/housing association dwelling in Lothian Region

Please turn to the next page

4. **How many times have you ever bought a dwelling?**

☐ one ☐ two ☐ three ☐ four ☐ five or more

5. **Please estimate when your dwelling was built:**

☐ before 1919 (incl.1919)
☐ between 1920-1945(incl.1945)
☐ between 1946- 1959(incl.1959)
☐ 1960 or later
☐ I don't know.

6. **The dwelling is a:** ☐ Detached house
☐ Semi-detached house
☐ Terraced house
☐ Flat with own main entrance
☐ Flat with shared main entrance

7. **Please state the TOTAL number of ROOMS in your dwelling (incl. bathrooms and kitchen)** ____________.

8. **Please tick all the attributes your dwelling has:**

Number	Dwelling attribute	Tick
1	Spacious kitchen with a dining area	
2	Garage	
3	Own private parking area (not a garage)	
4	Central heating	
5	Second bathroom/toilet	
6	Garden	

9. **From the above SIX housing attributes, please choose the THREE MOST IMPORTANT to you, taking account of what you can afford. They NEEDN'T NECESSARILY be in your present dwelling.**

Number

☞ The MOST important attribute is ______

☞ The SECOND MOST important attribute is ______

☞ The THIRD MOST important attribute is ______

Please turn to the next page

10. **Please use a tick to describe the physical condition of your neighbourhood: (e.g. state of neighbourhood housing etc.)**

- ☐ Excellent
- ☐ Improving
- ☐ Sound
- ☐ Deteriorating
- ☐ Poor

11. **Please answer the following questions. If you are not sure for some questions, please put '*' in the blanks.**

- How long do you **USUALLY** take to reach the main **SHOPPING AREA** which you **MOSTLY** use?

  About __________minutes.

- By what **TRANSPORT METHOD** do you get there? ______.

- How **CLOSE** is your dwelling to the **NEAREST PUBLIC TRANSPORT FACILITY**, if **WALKING**?

  (e.g. bus stop or train station)

  About________minutes.

- If you have school age children, how long do they **USUALLY** need to get to **SCHOOL**?

  About__________minutes.

- By what **TRANSPORT METHOD** do they get there?_______.

Please turn to the next page

Section III Based on your present **CIRCUMSTANCES** (i.e. your present job, income and family size), please **RANK** the following housing attributes in each box, in order of importance to you when choosing a dwelling. Please do so whether you are currently choosing a dwelling or not.

Box 1 1=The most important attribute,
2=The second most important attribute,
3=The third most important attribute,
4=The fourth most important attribute.

RANK	Dwelling attribute
	Close to the head of the household's place of work or potential work
	Good transport links (e.g. bus, train, motorways)
	Good neighbourhood (e.g. neighbourhood amenities or state of neighbourhood housing)
	A dwelling of better quality (e.g. more rooms, or in better condition)

Box 2 1=The most important attribute,
2=The second most important attribute,
3=The third most important attribute.

RANK	Dwelling attribute
	Type of dwelling (e.g. house or flat)
	Size of dwelling (e.g. more or bigger rooms)
	Age of dwelling

Box 3 1=The most important attribute,
2=The second most important attribute.

RANK	Housing attribute
	Physical condition of the neighbourhood (e.g. state of neighbourhood housing etc.)
	Good neighbourhood amenities (e.g. shops, schools, leisure amenities)

Please turn to the next page

If you would be willing to be interviewed further on this topic, please tick this box ☐ and give your phone number ____________ or your address ____________________________.

Please post your completed form in the envelope provided (no stamp required).

Thank you very much for your time

Yours Sincerely

Mrs Yong Tu
Research student
Department of Industrial and Social Studies
Napier University

Appendix 7-1
Maps and Submarket Classification in Lothian Region

Map One: The Lothian Region Private Owner-Occupier Housing Market Boundary

Map Two: Lothian Region Neighbourhood Housing Submarket Classification

Map Three: Edinburgh Neighbourhood Housing Submarket Classification

Map Four: Lothian Region Shopping Hierarchy

Map Five: Edinburgh Shopping Hierarchy

Map Six: Lothian Region High School Distribution

Map Seven: Edinburgh High School Distribution

Table 1: Lothian Region and Edinburgh High School Quality

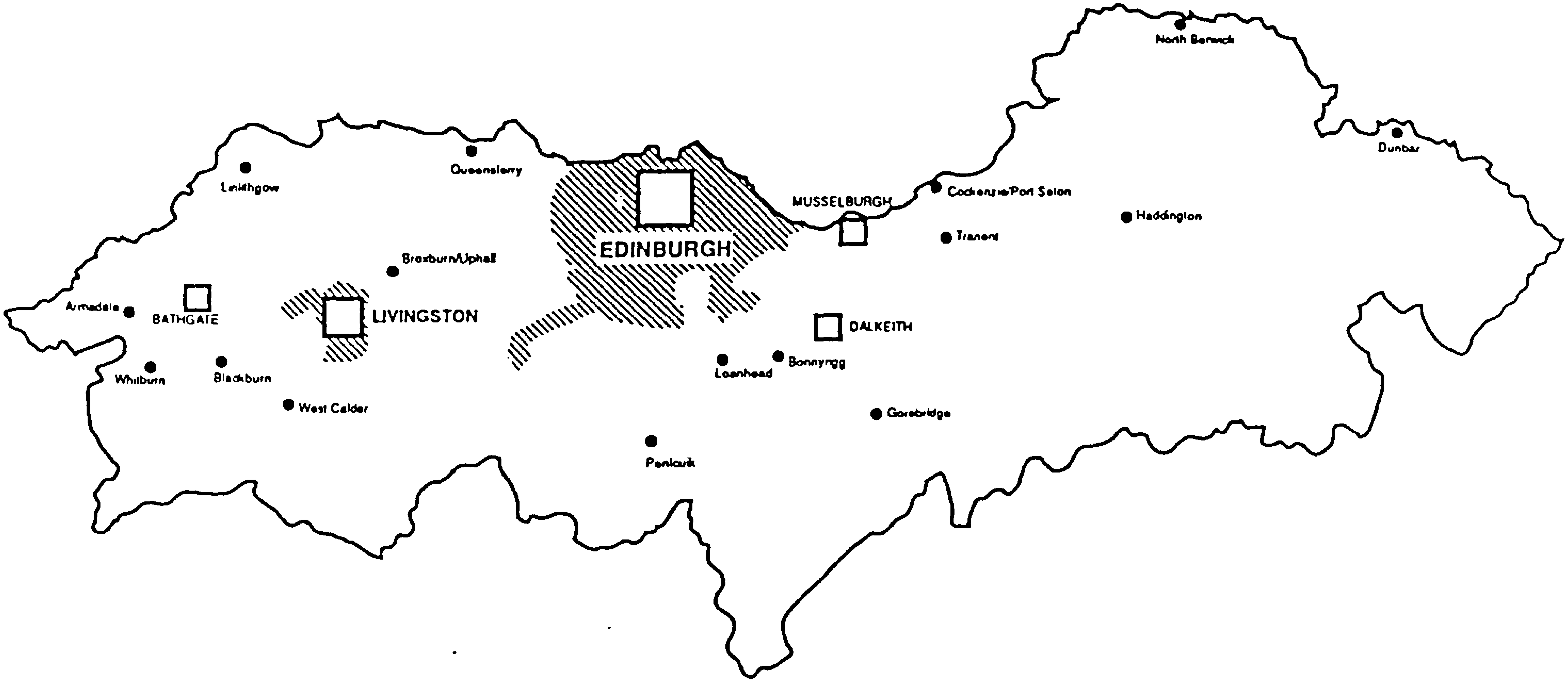
Sources of all the above except Maps Two and Three are from Lothian Region Structure Plan 1993. Maps Two and Three are drawn on the basis of Register of Sasine data and ESPC data.

Map One: The Lothian Region Private Owner-Occupier Housing Market Boundary

Area of Improving Marketability

Map Two: Lothian Region Neighbourhood Housing Submarket Classification

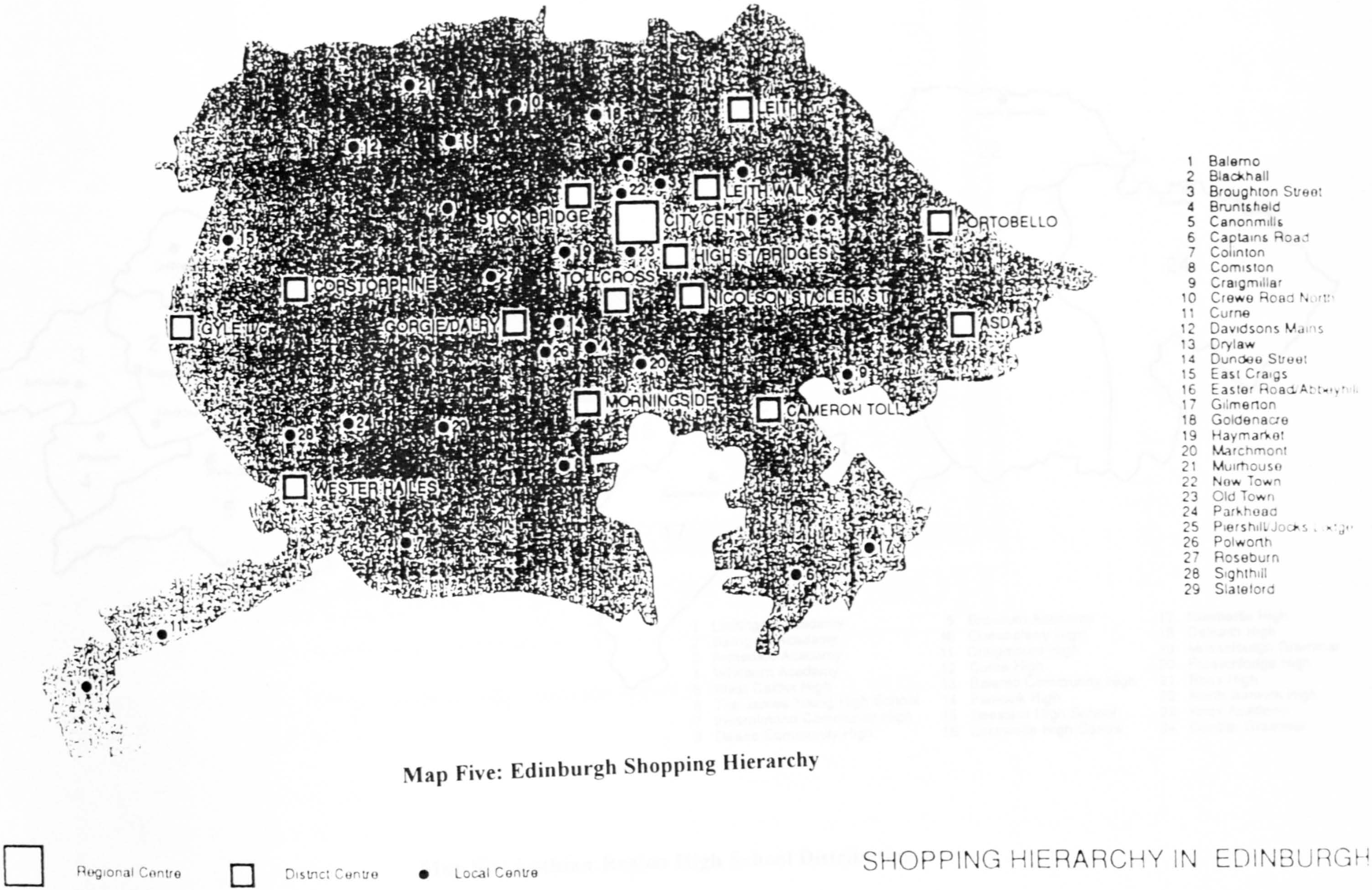
Map Three: Edinburgh Neighbourhood Housing Submarket Classification



Map Four: Lothian Region Shopping Hierarchy

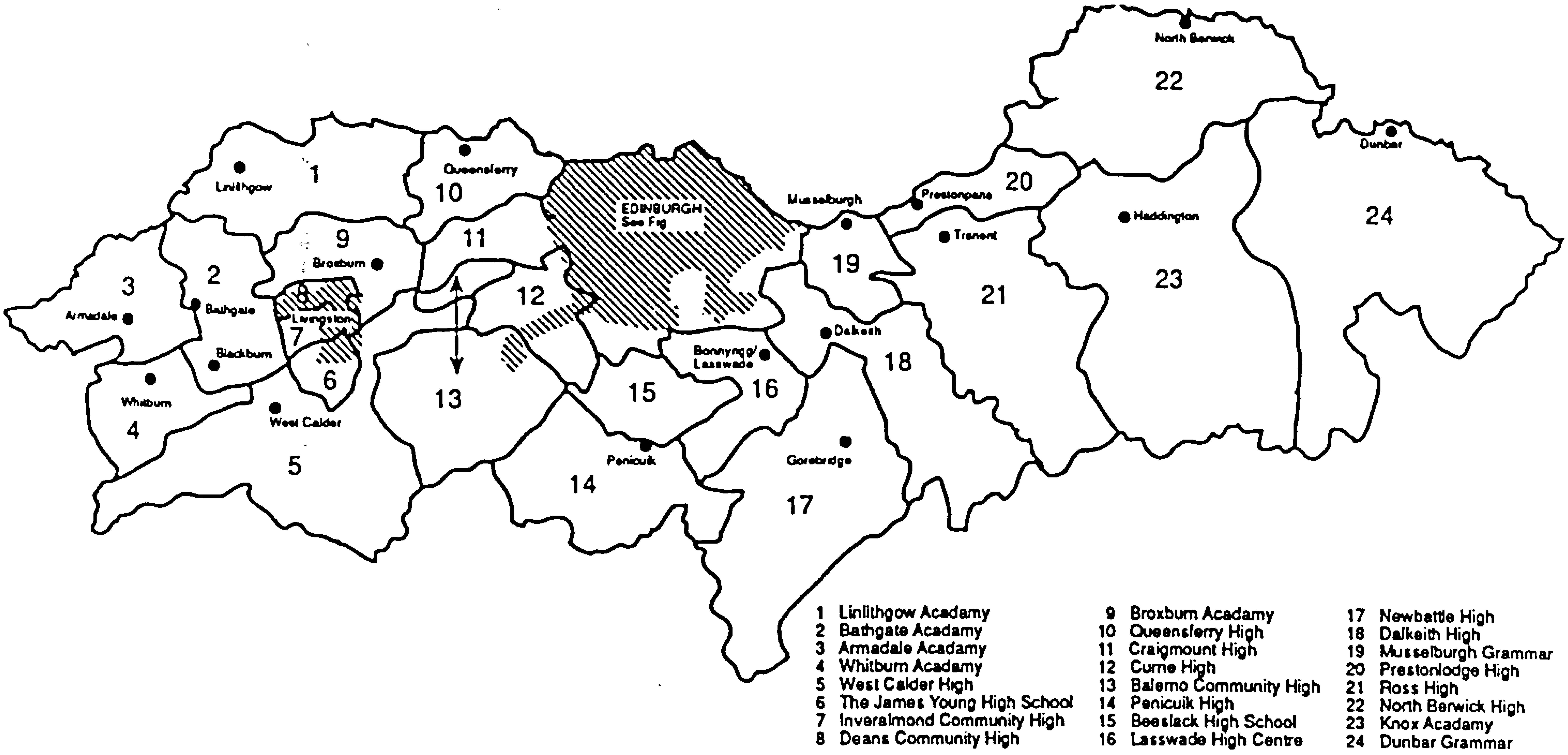
Regional Centre
District Centre
Sub Regional Centre [Planned]
Local Centre

SHOPPING HIERARCHY IN LOTHIAN



Map Five: Edinburgh Shopping Hierarchy

SHOPPING HIERARCHY IN EDINBURGH



Map Six: Lothian Region High School Distribution

Table 1: Lothian Region and Edinburgh High School Quality

How our schools compare

Percentage of 1989-90 school leavers with 5 or more Highers (bands A-C)

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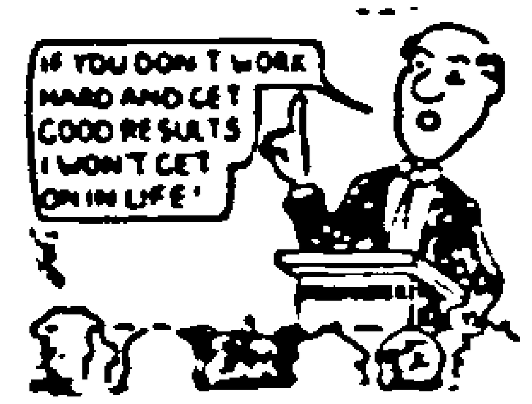


Table 2

Sub-Market	11	12	13	14	21	22	23
1	£29,528 (77)	£36,996 (23)	£44,658 (40)	£42,867 (6)	£16,950 (3)	£16,950 (2)	£33,000 (3)
2	£36,604 (19)	£33,926 (34)	£57,946 (9)	£44,833 (8)	£30,226 (10)	£30,226 (12)	£39,856 (10)
3	£38,655 (5)	£38,214 (17)	£50,000 (1)	£45,013 (2)	£43,704 (13)	£43,704 (6)	£41,583 (3)
4	£40,508 (11)	£40,000 (5)	£63,394 (21)	£83,333 (1)	£30,000 (1)	£30,000 (1)	£29,000 (1)
5	£43,384 (14)	£48,884 (16)	£71,697 (14)	£68,807 (7)	£36,248 (8)	£36,248 (13)	£46,500 (4)
6	£35,095 (5)	£56,707 (38)	£80,986 (11)	£77,057 (19)	£50,018 (22)	£50,018 (20)	£60,798 (15)
7	£24,000 (1)	£60,000 (2)	£86,241 (5)	£74,735 (5)	£37,555 (7)	£37,555 (1)	£75,500 (1)
8	109,327 (4)	£75,210 (11)	122,786 (5)	130,405 (21)	£75,807 (22)	£75,807 (21)	£50,875 (2)
9	111,000 (1)	£75,210 (23)	(----) (0)	(----) (0)	(----) (0)	(----) (0)	£76,244 (15)
Average	£36,227 (137)	£52,731 (169)	£72,695 (106)	£84,741 (69)	£40,309 (86)	£49,867 (76)	£54,088 (54)

Note: 1. The number in the bracket is sample size and the sum of the sample sizes is 697. However, in the empirical analyses, 710 sample points are used, the extra 13 sample points are the artificial sample points. They are created in order to suit to the need of the model calibration (see Chapter VI).

2. In the table, the codes 11 to 14, 21 to 23 represent different neighbourhood submarkets which are marked in Map Two and Three. The codes 1 to 9 represent different sectoral housing submarkets. The definitions of the codes are given below.

Table 2 gives the average house price (in 1989) and the sample size in each neighbourhood and sectoral housing submarket. The codes used in the table correspond to the codes in Maps Two and Three.

Each of the Codes of 11 to 23 corresponds to the following district wards.

11=Pilton, Muirhouse, Newhaven, Broughton, Lorne, Fort Harbour, Lochend, Links, Haymarket, St.Giles, Holyroad, N.Hailes, S.Hailes, Sighthill, Moat, Stenhouse, Dalry, Firrhill.

12=SW/SE.Corstorphine, Telford, Trinity, Craigentinny, Willowbrace, Portbello, Milton, Kaimes, Alnwickhill, Inch, Gilmerton, Niddire, Craigmillar, Longstone,Queensferry, Kirkliston, Baberton, Ratho, Currie, Bonnyrigg, Polton, Lasswade, Biliston, Musselburgh, Tranent, Wallyford, Elphinstone.

13=Murrayfield, Dean, New Town, Stockbridge, Inverleith, Calton, Tollcross, Merchiston, Morningside, Sciennes, Marchmont, Prestonfield, Mayfield, Shandon.

14=Parkgrove, NW/NE.Corstorphine, Mountcastle, Cramond, Blackhall, Colinton, Braidburn.

21=Armadale, Bathgate, Blackburn, Westfield, Whitburn, Fauldhouse, Longridge, Livingston, East Calder, Mid Calder, West Calder, Ladywell, Pumpherston.

22=Linlithgow, Gorebridge, Penicuik, Rosewell.

23=Haddington, North Berwick, Dunbar.

Each of the codes 1 to 9 are defined below:

1=Flat with less than or equal to two bedrooms.

2=Main door flat or terraced house with less than or equal to two bedrooms.

3=Detached- / semi- detached house with less than or equal to two bedrooms.

4=Flat with three or four bedrooms.

5=Main door flat or terraced house with three or four bedrooms.

6=Detached / semi-detached house with three or four bedrooms.

7=Flat with five or more bedrooms.

8=Main door flat or terraced house with five or more bedrooms.

9=Detached / semi-detached house with five or more bedrooms.

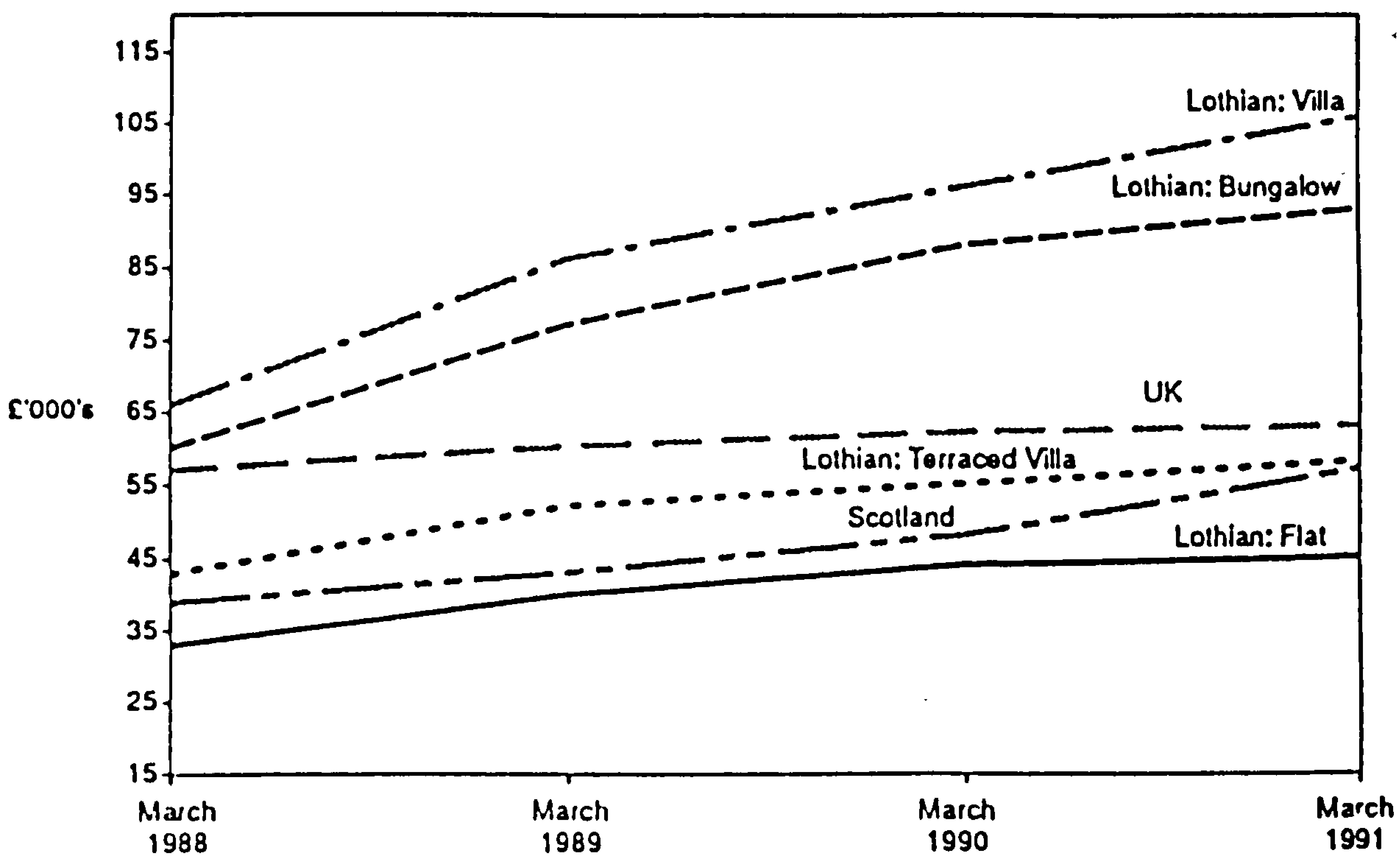
Appendix 7-2

Supplementary Information

Part One The Dynamics of House Prices in Lothian Region, Scotland and the UK

Diagram 1

Average House Prices 1988 to 1991 for Lothian Region, Scotland and the UK



Source : Edinburgh Solicitors Property Centre and Halifax Building Society House Price Index

Part Two Lothian Region 1992 Housing and Household Survey Results

The information presented below includes three sections corresponding to the questionnaire structure: (the number in the bracket is the sample size)

1. Socio-Economic Background of the Head of Household

Table 1: Sex

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Male	68.8	47.5	71.6	76.4	67.4
Female	31.2	52.5	28.4	23.6	32.6
Total	100 (677)	100 (122)	100 (148)	100 (309)	100 (98)

Note: Stage-I=Young single households;
Stage-II=Young couple households without children;
Stage-III=Households with dependent children;
Stage-IV=Older households without children.

Table 2: Marriage Status

%	Overall
1	70.7
2	19.0
3	2.6
4	7.7
Total	100 (679)

Note: 1=married/long term partner; 2=single; 3=window/er; 4=Divorced/separate.

Table 3: Employment Status

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Full-time	74.3	88.4	87.8	78.4	25.6
Part-time	3.5	1.5	1.4	3.2	9.9
Self-employed	9.8	6.0	7.4	12.3	10.8
Un-employed	4.0	3.3	2.7	3.9	6.7
Retired	7.1	0	0	0.3	47.0
Student	1.3	0.8	0.7	1.9	0.0
Total	100 (681)	100 (122)	100 (148)	100 (310)	100 (101)

Table 4: Profession

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Managerial/ Supervisory	27.7	25.0	32.8	31.2	12.9
Professional person	43.1	50.0	47.3	44.6	24.8
Skilled worker	14.8	16.4	16.4	15.4	8.9
Semi-skilled worker	3.0	3.4	1.4	3.9	2.0
Others	11.4	5.2	2.1	4.9	51.4
Total	100 (670)	100 (116)	100(148)	100 (305)	100 (101)

Table 5: Transportation To Work Methods

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Car/Van	62.6	52.5	71.2	72.2	32.3
Train	2.1	3.3	4.1	1.0	1.0
Bus	15.7	26.7	17.1	12.9	9.1
Walk/bike	7.4	12.5	4.1	8.4	3.0
Others	12.2	5.0	3.5	5.5	54.6
Total	100 (674)	100 (120)	100 (146)	100 (309)	100 (99)

Table 6: Travel To Work Time

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
< 30 mins	60.9	70.0	59.9	66.3	34.7
30-60 mins	21.0	20.8	32.0	21.2	4.1
60-90 mins	4.6	4.2	4.8	4.3	6.1
> 90 mins	1.2	0	0	2.6	0
Varies	12.3	5.0	3.3	5.6	55.1
Total	100 (671)	100 (120)	100 (147)	100 (306)	100 (98)

Table 7: Highest Educational Level

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Degree or equal	39.6	50.1	46.7	34.1	32.6
Qualifica-tion	23.1	18.0	18.2	25.0	31.5
'A' level or Higher	14.2	16.4	12.8	15.6	9.0
'O' level or 'O' Grade	16.6	13.9	18.2	18.5	11.2
Others	6.5	1.6	4.1	6.8	15.7
Total	100 (667)	100 (122)	100 (148)	100 (308)	100 (89)

2. Socio-Economic Background of the Households

Table 8: Annual Household Income Before Tax

1992 (£)

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
<10,000	11.4	14.1	2.7	8.5	31.5
10,000-15,000	14.4	28.1	4.8	10.1	26.1
15,000-20,000	18.6	29.8	11	20.9	8.7
20,000-25,000	17.7	13.2	25.3	19.2	6.5
25,000-30,000	12.5	8.3	20.0	12.1	7.6
30,000-35,000	8.1	3.3	10.3	10.1	4.4
35,000-40,000	8.4	3.3	15.8	7.8	5.4
40,000-50,000	4.1	0	5.4	5.2	3.3
>50,000	4.8	0	4.8	6.2	6.5
Total	100 (666)	100 (121)	100 (146)	100 (307)	100 (92)

Table 9: Sources of Owner Occupier Housing Demand

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
1	23.8	19.6	21.6	23.2	33.6
2	16.0	27.1	23.0	12.3	4.0
3	45.2	27.1	38.5	52.2	55.4
4	9.7	21.3	13.5	5.5	3.0
5	4.7	4.9	2.7	6.5	2.0
others	0.6	0	0.7	0.3	2.0
Total	100 (681)	100 (122)	100 (148)	100 (310)	100 (101)

Note: *1. From outside the Region;*
2. From the shared Dwelling;
3. From the Lothian Region owner occupier housing market;
4. From the Lothian Region private rental housing market;
5. From the Lothian Region council/housing association dwelling;
6. Others: e.g. tied houses.

Table 10: Experiences in Housing Market

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
1	32.9	60.7	41.2	25.4	10.0
2	30	27.8	37.2	29.0	25.0
3	20.1	9.0	15.5	25.4	24.0
4	10.6	2.5	5.4	14.0	18.0
5 or more	6.4	0	0.7	6.2	23.0
Total	100 (677)	100 (122)	100 (148)	100 (307)	100 (100)

Note: The code represents how many times a housheold have ever bought a dwelling (including this time).

Table 11: Dwelling Age

%	Overall	Group-1	Group-2	Group-3	Group-4
before 1919	31.5	50.0	36.5	24.5	23.8
1920-1945	11.0	7.4	9.5	12.3	13.9
1946-1959	7.1	0.8	2.0	11.6	7.9
1960 later	50.4	41.8	52.0	51.6	54.4
Total	100 (681)	100 (122)	100 (148)	100 (310)	100 (101)

Table 12: Dwelling Type

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Detached House	20.0	3.3	13.5	27.1	27.8
Semi-detached House	20.7	8.2	20.3	27.2	16.8
Terraced House	18.7	7.4	21.6	20.6	21.8
Main Door Falt	12.2	18.9	10.8	10.6	10.7
Flat	28.4	62.2	33.8	14.5	22.9
Total	100 (681)	100 (122)	100 (148)	100 (310)	100 (101)

Table 13: Dwelling Size

Mean	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Num. of Bedrooms	3.1	1.8	2.9	2.9	3.2

Table 14: Physical Neighbourhood Condition

	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Excellent	48.1	33.3	40.4	51.0	68.0
Improving	21.3	33.3	22.6	18.6	13.0
Sound	26.5	29.2	31.5	26.8	15.0
Deteriorat	3.1	1.7	4.8	2.6	4.0
Poor	1.0	2.5	0.7	0.9	0
Total	100 (672)	100 (120)	100 (146)	100 (306)	100 (100)

Table 15: Time To Shopping Area

Mean	Overall	Stage-I	Stage-II	Stage-III	Stage-III
Minutes	9.3	8.2	10.1	9.4	9.4

Table16: Time to School

Mean	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Minutes	5.74	---	---	5.74	---

Table 17: Non-key Dwelling Components RP Preference

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Large Kitchen	48.3	33.3	48.0	53.1	52.0
Central Heating	84.6	64.2	84.5	89.6	94.0
Private Garden	74.6	38.3	68.2	89.6	81.0
Garage	35.6	14.2	29.1	43.0	48.0
Private Parking	45.9	34.2	43.2	51.1	48.0
Second Bathroom	25.6	5.8	17.6	33.7	36.0
All	(677)	(120)	(148)	(309)	(100)

3. Stated Housing Choice

Table 18: Stated Preference of Neighbourhood vs Dwelling

The most important component

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Close to work Place	8.5	13.2	8.8	6.2	9.7
Good Transport Links	9.3	9.1	6.1	8.2	18.5
Good Neighbour -hood	44.8	44.6	39.5	47.0	44.9
Better quality of dwelling	37.4	33.1	45.6	38.6	26.9
Total	100 (672)	100 (121)	100 (147)	100 (306)	100 (98)

Note: The meaning of the percentage figures is, for example, overall 44.8% households out of 672 housheolds think that 'Good neighbourhood Condition' is the most important component to be considered compared with the other three comopnents. However, the survey shows that some respondents find it is difficult to compare 'near to the work place' with others. This question leads to to some misunderstanding.

Table 19: Stated Preference for Dwelling

The Most Important Component

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Type	45.1	31.4	45.2	42.3	70.8
Size	50.5	62.8	48.6	55.7	20.8
Age	4.4	5.8	6.2	2.0	8.4
Total	100 (668)	100 121)	100 (146)	100 (305)	100 (96)

Note: The meaning of the percentage figures is, for example, overall 45.1% households out of 668 housheolds think that 'Dwelling type' is the most important component to be considered compared with the other two comopnents.

Table 20: Stated Preference for Neighbourhood Condition

The Most Important Componet

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Good Physical Neighbou-rhood	70.0	71.1	76.7	66.3	69.8
Good Neighbour-hood Amenties	30.0	28.9	23.3	33.7	30.2
Total	100 (669)	100 (121)	100 (146)	100 (306)	100 (96)

Note: The meaning of the percentage figures is, for example, overall 70% households out of 669 housheolds think that 'Good physical neighbourhood' is the most important component to be considered compared with 'Good neighbourhood amenties'.

Table21: Stated Preferences: the most Important Non-key Dwelling Component

%	Overall	Stage-I	Stage-II	Stage-III	Stage-IV
Large Kitchen	31.0	37.4	32.5	26.7	36.0
Central Heating	48.6	46.9	51.3	48.5	47.0
Private Garden	15.1	9.6	14.2	19.5	9.0
Garage	2.1	5.2	0	1.0	3.0
Private Parking	1.2	0.9	2.0	1.3	1.0
Second Bathroom	2.0	0	0	3.0	4.0
All	100 (664)	100 (115)	100 (146)	100 (303)	100 (100)

Note: The meaning of the percentage figures is, for example, overall 31% households out of 664 housheolds think that 'Large kitchen' is the most important component to be considered compared with the other five comopnents.

Appendix 7-3
Statistical Software Package: LIMDEP 6.0

Limdep is a statistical software package, which is very good at calibrating discrete choice model.

This appendix gives the data structure required by the Limdep discrete choice modelling program (see Chapter 41 in Limdep 6.0). The data in the table corresponds to only one sample point. Each raw represents one sectoral housing submarket denoted by 'SMKT'. Each column represents one variable. 'Dep' is the dependent variable with '1' denoting the submarket chosen by this individual and '0' denoted the submarkets which were not chosen. 'Indj' and Indi' are the variables converted from 'Dep'. This coding is required by the procedure. 'Dprice' is the average sectoral submarket house price.

INCOME	SMKT	Indj	Indi	DEP	DPRICE	TYPE2	TYPE3	SIZE
12500	111	1	-2	1	29528	0	0	1
12500	112	0	-2	0	36604.73	1	0	1
12500	113	0	-2	0	38655.19	0	1	1
12500	114	0	-2	0	40507.73	0	0	2
12500	115	0	-2	0	43383.92	1	0	2
12500	116	0	-2	0	35095.19	0	1	2
12500	117	0	-2	0	24000	0	0	3
12500	118	0	-2	0	109327	1	0	3
12500	119	0	1	0	111000	0	1	3
12500	121	-3	-2	0	36996.21	0	0	1
12500	122	-3	-2	0	33926.35	1	0	1
12500	123	-3	-2	0	38213.69	0	1	1
12500	124	-3	-2	0	41340	0	0	2
12500	125	-3	-2	0	48884.12	1	0	2
12500	126	-3	-2	0	56707.12	0	1	2
12500	127	-3	-2	0	60000	0	0	3
12500	128	-3	-2	0	75210	1	0	3
12500	129	-3	0	0	75210	0	1	3
12500	131	-3	-2	0	44658.28	0	0	1
12500	132	-3	-2	0	57946.89	1	0	1
12500	133	-3	-2	0	50000	0	1	1
12500	134	-3	-2	0	63394.42	0	0	2
12500	135	-3	-2	0	71697	1	0	2
12500	136	-3	-2	0	80986.17	0	1	2
12500	137	-3	-2	0	86241.39	0	0	3
12500	138	-3	-2	0	122786.2	1	0	3
12500	139	-3	0	0	140000	0	1	3
12500	141	-3	-2	0	42866.67	0	0	1
12500	142	-3	-2	0	44832.87	1	0	1
12500	143	-3	-2	0	45013	0	1	1
12500	144	-3	-2	0	83333	0	0	2
12500	145	-3	-2	0	68806.71	1	0	2
12500	146	-3	-2	0	77057	0	1	2
12500	147	-3	-2	0	74735.2	0	0	3
12500	148	-3	-2	0	130405	1	0	3
12500	149	-3	0	0	140000	0	1	3
12500	211	-3	-2	0	18050	0	0	1
12500	212	-3	-2	0	27279	1	0	1
12500	213	-3	-2	0	34236.92	0	1	1
12500	214	-3	-2	0	39950	0	0	2
12500	215	-3	-2	0	31431.25	1	0	2
12500	216	-3	-2	0	38545	0	1	2
12500	217	-3	-2	0	40056.42	0	0	3
12500	218	-3	-2	0	57946.08	1	0	3
12500	219	-3	-2	0	60000	0	1	3
12500	221	-3	-2	0	16950	0	0	1
12500	222	-3	-2	0	30225.83	1	0	1
12500	223	-3	-2	0	43704.32	0	1	1
12500	224	-3	-2	0	30000	0	0	2
12500	225	-3	-2	0	36248.23	1	0	2
12500	226	-3	-2	0	50018.05	0	1	2
12500	227	-3	-2	0	37555	0	0	3
12500	228	-3	-2	0	75807.32	1	0	3
12500	229	-3	-2	0	80000	0	1	3
12500	231	-3	-2	0	33000	0	0	1
12500	232	-3	-2	0	39855.5	1	0	1
12500	233	-3	-2	0	41583.32	0	1	1
12500	234	-3	-2	0	29000	0	0	2
12500	235	-3	-2	0	46500	1	0	2
12500	236	-3	-2	0	60798.39	0	1	2
12500	237	-3	-2	0	75500	0	0	3
12500	238	-3	-2	0	50875	1	0	3
12500	239	-3	-2	0	76244.73	0	1	3

AGE	VEC2	VEC3	NPNC	NNAM	NSCH	DTW	NVEC2	NVEC3
1.82	0	1	1	3	0.07	1	0	1
2.52	1	0	1	3	0.07	1	0	1
3	0	0	1	3	0.07	1	0	1
1.91	0	0	1	3	0.07	1	0	1
2.89	1	0	1	3	0.07	1	0	1
3.4	0	0	1	3	0.07	1	0	1
1	0	0	1	3	0.07	1	0	1
1.75	0	0	1	3	0.07	1	0	1
1	0	0	1	3	0.07	1	0	1
2.57	1	0	2	2	0.162	1	0	1
3.12	0	1	2	2	0.162	1	0	1
3.47	1	0	2	2	0.162	1	0	1
2.2	0	0	2	2	0.162	1	0	1
3.06	1	0	2	2	0.162	1	0	1
3.68	0	1	2	2	0.162	1	0	1
3	0	0	2	2	0.162	1	0	1
1.55	0	0	2	2	0.162	1	0	1
3	1	0	2	2	0.162	1	0	1
1.98	0	1	2	3	0.25	1	1	0
1.56	0	0	2	3	0.25	1	1	0
4	0	0	2	3	0.25	1	1	0
1.9	0	1	2	3	0.25	1	1	0
1.57	1	0	2	3	0.25	1	1	0
2.45	1	0	2	3	0.25	1	1	0
2.2	0	0	2	3	0.25	1	1	0
1.8	0	0	2	3	0.25	1	1	0
2	0	0	2	3	0.25	1	1	0
3.5	0	0	3	3	0.179	1	0	0
3.5	1	0	3	3	0.179	1	0	0
4	0	0	3	3	0.179	1	0	0
1	0	0	3	3	0.179	1	0	0
2.43	1	0	3	3	0.179	1	0	0
2.74	0	1	3	3	0.179	1	0	0
3.2	0	0	3	3	0.179	1	0	0
2.43	0	1	3	3	0.179	1	0	0
2.5	0	0	3	3	0.179	1	0	0
4	0	0	1	2	0.087	2	1	0
3.7	1	0	1	2	0.087	2	1	0
3.69	1	0	1	2	0.087	2	1	0
4	0	0	1	2	0.087	2	1	0
3.38	0	0	1	2	0.087	2	1	0
3.91	0	1	1	2	0.087	2	1	0
2.57	0	0	1	2	0.087	2	1	0
3.86	0	1	1	2	0.087	2	1	0
4	0	0	1	2	0.087	2	1	0
2	0	0	2	1	0.17	2	1	0
3.75	1	0	2	1	0.17	2	1	0
3.83	0	0	2	1	0.17	2	1	0
1	0	0	2	1	0.17	2	1	0
2.92	1	0	2	1	0.17	2	1	0
4	0	1	2	1	0.17	2	1	0
4	0	0	2	1	0.17	2	1	0
2.86	0	1	2	1	0.17	2	1	0
3	0	0	2	1	0.17	2	1	0
1	0	0	3	1	0.202	2	0	0
2.7	1	0	3	1	0.202	2	0	0
3	0	0	3	1	0.202	2	0	0
1	0	0	3	1	0.202	2	0	0
2.5	0	0	3	1	0.202	2	0	0
3.67	0	1	3	1	0.202	2	0	0
4	0	0	3	1	0.202	2	0	0
2.5	0	0	3	1	0.202	2	0	0
2.93	0	1	3	1	0.202	2	0	0

Appendix 7-4

The Definitions of the Independent Variables

Table 1

Sectoral Housing Submarket

Variable Names	Variable Definitions
HRPI	The ratio of average sectoral submarket house price to household annual income. This is a continuous variable.
VEC	The marketability of a sectoral housing submarket. It is measured by Low, Middle and High three levels defined in (Section 7.3).

The dummy variables are:

VEC1	VEC2	VEC3	VEC
0	0	0	Low
0	1	1	Middle
0	0	1	High

TYPE — The dummy variables of dwelling type components.

	TYPE1	TYPE2	TYPE3
Detached-semi-detached	0	1	0
Main door flat or Terraced house	0	0	1
Flat	0	0	0

SIZE — The average size of the dwellings in each sectoral submarket. It is measured by the total number of bedrooms in a dwelling. This number is equal to the total number of rooms-the number of kitchens - the number of bathrooms-1. The average size is converted to an ordinal variable.

Size=1 if the number of bedrooms is 2 or below;
Size=2 if the number of bedrooms is 3 or 4;
Size=3 if the number of bedrooms is 5 or over.

AGE — The average age of the dwellings in each sectoral submarket. This is an ordinal variable:

1= before 1919;
2=between 1920-1945
3=between 1946-1959
4=after 1960

Table 2

Neighbourhood Housing Submarket

Variable Names	Variable Definitions
NRPI	Average neighbourhood house price to household income. This is a continuous variable.
NVEC	The marketability of a neighbourhood housing submarket It is measured by Low, Middle and High three levels defined in (Section 7.3). The dummy variables are:

NVEC1	NVEC2	NVEC3	NVEC
0	0	0	Low
0	1	1	Middle
0	0	1	High

NNAM	Neighbourhood amenities is described by an ordinal variable: 1=near to the local shopping centre only; 2=near to the district shopping centre; 3=near to the regional shopping centre.
NPNC	Physical neighbourhood condition is measured by the average rate of the buyers' assessment of their physical neighbourhood condition in a neighbourhood submarket. This variable is an ordinal variable and constructed by the respondents' rating: 1=Sound; 2=Improving; 3=Excellent.
NSCH	The secondary school quality of a neighbourhood. It is a continuous variable measured by the average percentage of 1989-90 school leavers with '5 or more Highers' in a neighbourhood.

DTW The distance to the work place of the head of a household. It is measured by an ordinal variable. Lothian Region housing market is divided into five locations:

a=Edinburgh,
b=Midlothian (Code 22 in MapTwo of Appendix 7-1),
c=Linlithgow (Cpde 22 in Map Two of Appendix 7-1),
d=West Lothian (Code 21 in Map Two of Appendix 7-1)
e=East Lothian (Code 23 in Map Two of Appendix 7-1)

The ordinal varable is constructed by:

1=living and working in the same location;
2=living in a location adjacent to the location of the work place.
If working in 'a', the adjacent locations are 'b' to 'e';
If working in 'b', the adjacent location is 'a';
If working in 'c', the adjacent location is 'a' and 'd';
If working in 'd', the adjacent location is 'a' and 'c';
If working in 'e', the adjacent location is 'a'.

3=Otherwise.
If working in 'b', but living in location 'c' or 'd' or'e';
If working in 'c', but living in location 'b'or 'e';
If working in 'd', but living in location 'b' or 'e';
If working in 'e', but living in location 'b' or 'c'or 'd'.

Note: 1. the coding of 'DTW' is based on the geographic distance as well as the facilities of the transport link between the locations (Lothian Regiona Structure Plan 1992).

2. in Limdep discrete choice modelling procedure, an ordinal variable can be treated as a dummy variable or a continuous variable. In this study, both ways were used. The results showed that treating it as a continuous variable procided a good model fit.

Table 3

A Dwelling Given A Housing Sector

Variable names	Variable Descriptions
KITCHEN	Kitchen Type. KIT=1, representing large kitchen with a dinning area KIT=0, representing small kitchen with a separate dinning room.
CH	Central Heating. CH=1, a dwelling with central heating. CH=0, a dwelling without central heating.
GARDEN	Private Garden. GARD=1, a dwelling with a private garden. GARD=0, a dwelling without a private garden.

They are dummy variables.

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