

EVALUATION ON THE APPLICATION OF LIFE CYCLE MATRIX (LCM) IN FORECASTING HOUSING NEEDS AND HOUSING DEMAND IN DEVELOPED AND DEVELOPING COUNTRIES

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ABSTRACT: *The accuracy of forecasting of housing needs and demand is crucial to the preparation of development plan because residential land constitutes a greater share of the developed area of cities. Presently, many common methods are based on aggregate method, headship rates, household size, backlog and other accounting methods. Many of these methods have their strengths and weaknesses contributed by the assumptions and 'intelligent guesses' used in the calculations. This paper aims to explore alternative method of forecasting housing needs and demand by using Life Cycle Matrix. As a household undergoes change of stages in family life cycle, one's housing needs and demand are experiencing gradual change. Therefore, it is essential to consider the life cycle change of a household in the analysis and forecasting of housing needs and demands. Life Cycle Matrix was initiated in Japan in 1980s to estimate housing needs based on population cohort and household distribution pattern. Comparative analysis using LCM is also being carried out in developed countries (Japan and United Kingdom) and developing countries (Philippines and Malaysia).*

Keywords: Life Cycle Matrix, Housing Needs Analysis, Life Cycle Change Pattern, Japan, United Kingdom, Philippines

Introduction

Housing is a complex outcome of cultural, economic and regulatory environment (Tiwari, 2000). As a household undergoes change of stages in family life cycle, one's housing needs and demand are experiencing gradual change. Therefore, it is essential to consider the life cycle change of a household in the analysis and forecasting of housing needs and demands¹ (Yee 2002; Watkins, 2001, Lim, 2001, 2003; Tani, 1998; Ho,1994; Feitelson, 1993; Maclennan, 1992).

¹ The differences between housing needs and housing demand are that housing demand takes into account of the factors of affordability and purchasing power of a household (refer Field and Macgregor, 1987).

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The purpose of this paper is to focus on exploring an empirical method for assessing housing needs and three cases are being compared, namely Japan, United Kingdom and Philippines. However, due to availability of data, Japan is chosen as the main study case and its life cycle change and population structure will be discussed in detail. The authors found that there is a typical life cycle change pattern, which existed among developed and developing countries. Beside development status, time period is also another factor, which contributes to the changing pattern. By analysing the life cycle change pattern, the authors could easily forecast the future housing needs of a population.

One of the importance of this paper is to present an alternative method of housing needs and demand analysis because of the recent failure of effective housing planning has resulted to massive housing oversupply in Malaysia.(Alias 2007) This method which may require more aggregate and detail demographic data, but it will help to provide a better understanding of housing demand by population cohort and able to guide housing developers or housing planners at local authority to match their supply with the demand.

The Concept of Life Cycle Matrix (LCM)

Life Cycle Matrix (LCM) commonly refers to cross tabulation matrix between the household head's age and the size of household. A cell of matrix shows a group of household with similar age and household size. Housing needs of a household in each cell are based on the criteria of household size and age cohort. Therefore, if the distribution of the households in LCM shift, the housing needs for those population will also change.

² The number of categories vary and depend on census data, country's **development and economic** status. In other example, Yee (2002) analyses the household characteristics of Johor Bahru Metropolitan, Malaysia, by using 10 life cycle categories. See more examples in section 4

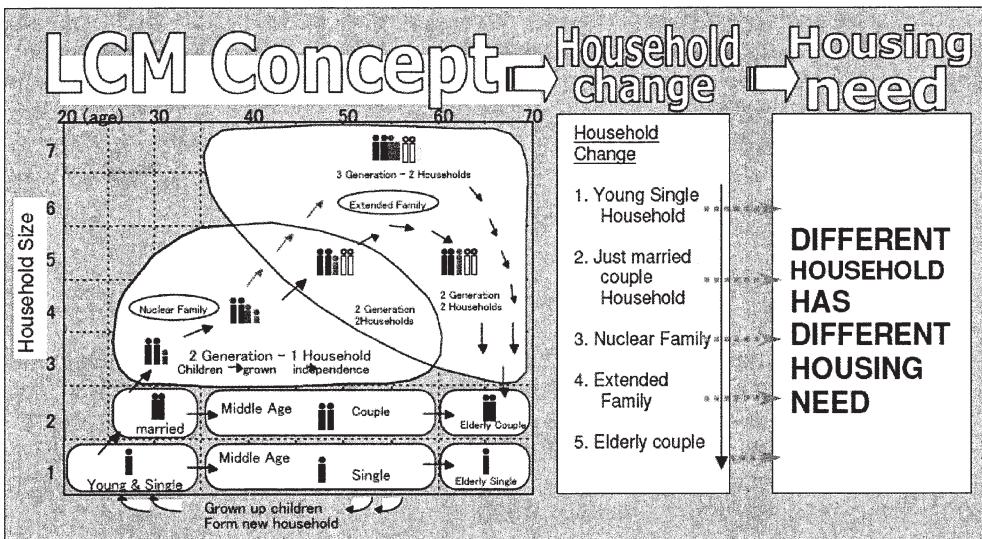


Figure 1: LCM concept

In the case of LCM of Japan, the life cycle is divided into twelve (12) cohorts² with interval of 5 years i.e., less than 25 years old, 25-29, 30-34, 35-39, 40-44, 45-50, 50-54, 55-59, 60-64, 65-69, 70-74, and more than 74 years old. The household size is again divided into 7 categories, 1 person, 2, 3, 4, 5, 6, and more than 6 persons per household. It forms a 12x7 matrix of households size with age cohorts. LCM helps to understand the housing need based on the demographic age cohort factor by identifying the sub markets.

The four (4) main components involved in this forecasting process are population structure, household head structure by age cohort, household size by cells of LCM, and housing tenure in each cell of LCM. In this process, household headship ratio and the percentage of household size by age cohort series will become the main parameters of LCM (for detailed explanation, please refer to section 6).

Application of LCM In Japan

Normally, there are three (3) different types of LCM pattern, namely by 'real number' (N_i), 'ratio total' ($N_i / \sum T_i$), and 'ratio cohort' (N_i / T_i).

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Real number LCM is used for comparing the changing size of household to age cohort according to time series. For example, in Figure 3a, LCM of Japan in 1968 shows a concentration of 4 persons per principle household³ in age cohorts of 30-34, 35-39 and 40-44 years old. This pattern changed in 1998, which showed a higher number of single household in young age cohort of less than 25 years old (1.7 millions). Presently there is a trend where younger generation tends to stay single and more independent. Another observed phenomenon is the increasing number of elderly couple and single. Those middle age (30-44 years old) households have changed gradually to smaller size. From this changing pattern, one will notice that elderly couples or singles, and young singles will continue to grow and thus, necessary efforts on providing small size housing or property policy should be given priority.

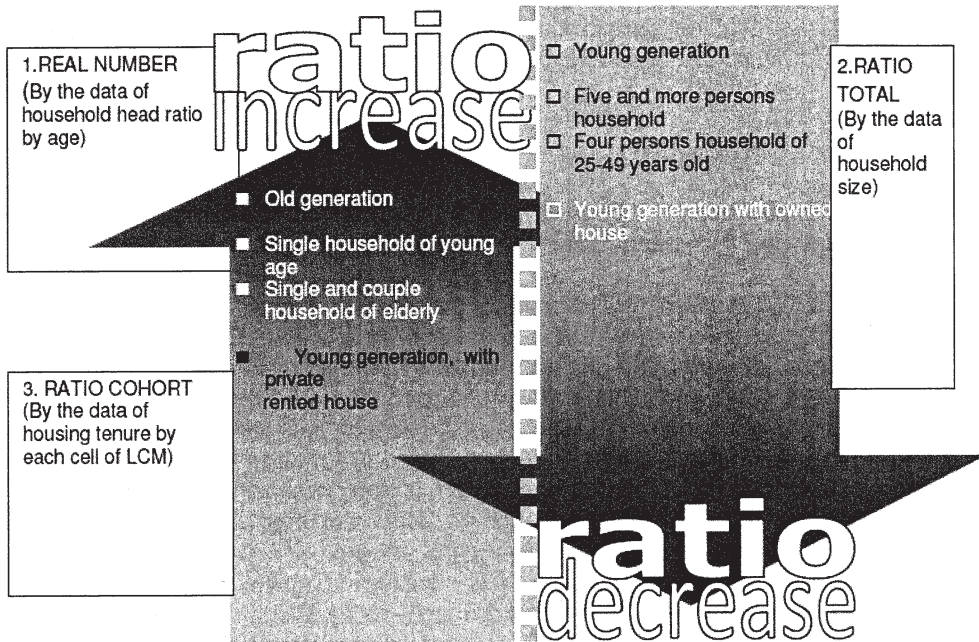
In 'ratio total' LCM, each cell of real number is divided by total number household in the same cohort. This can be done by summing up each cell to obtain a total - N_i , and then each total of the cell will be divided by this cell sum ($\sum T_i$). This type of LCM pattern shows a percentage distribution of each cell. Figure 3b shows higher percentage of cells happened in different time period and different age cohort: in 1968, 35-39 years old with 4 persons; but in 1998: elderly couple and single group. This morphology of change shows that Japan is moving towards an aging society with smaller household (1 to 3 persons).

The third LCM pattern - 'ratio cohort' pattern as shown in Figure 3, is based on a percentage of each cell against each cohort. The purpose of this 'ratio cohort' pattern is to understand the changing percentage and therefore facilitates the projection of real number. Different from 'ratio total', in 1968, high percentage of 30-44 years old households with 4 persons did not appear. It was due to distribution into other household size of 3 or 5 persons. Extended family is common in 1968 but slowly disappearing in today's Japanese society. This shows a trend that in developed country, such as Japan, the preference of higher household privacy and social independent is becoming more important. Besides, highest percentage of young single (about 80%) and elderly

³According to 1998 Housing and Land Survey of Japan, if a household occupied an entire dwelling, the household is defined as the "principle household". In the case that two or more households were living together in a dwelling, the owner of the dwelling—or, in the case that there is no owner living together, the chief lessee – is defined as the "principle household", and the others are defined as "lodging households".

couple (more than 64 years old) is clearly shown in 1998 'ratio cohort' pattern. This pattern remains dominant both in 'real number' or 'ratio total'.

Figure 2: Japan household ratio changing trend



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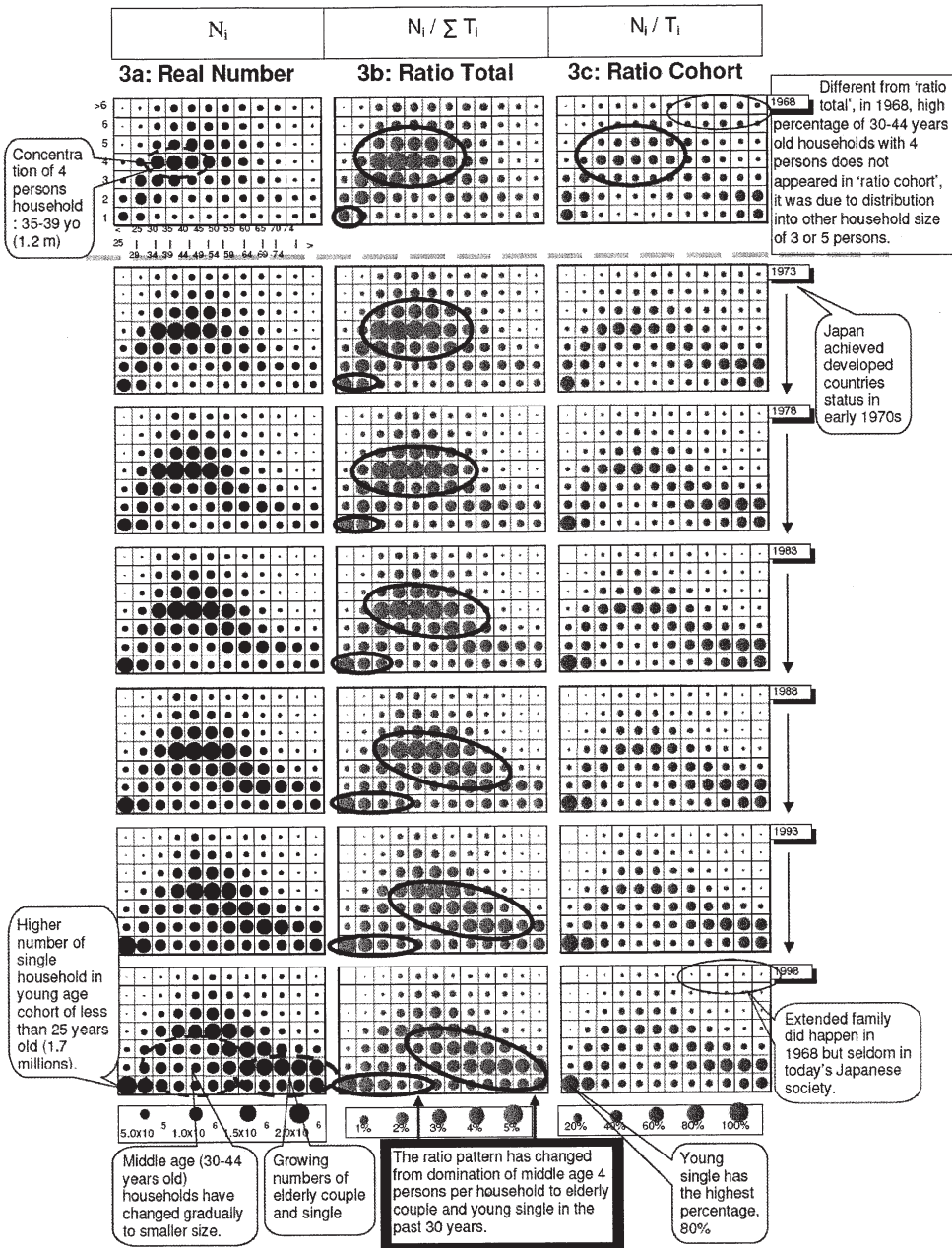
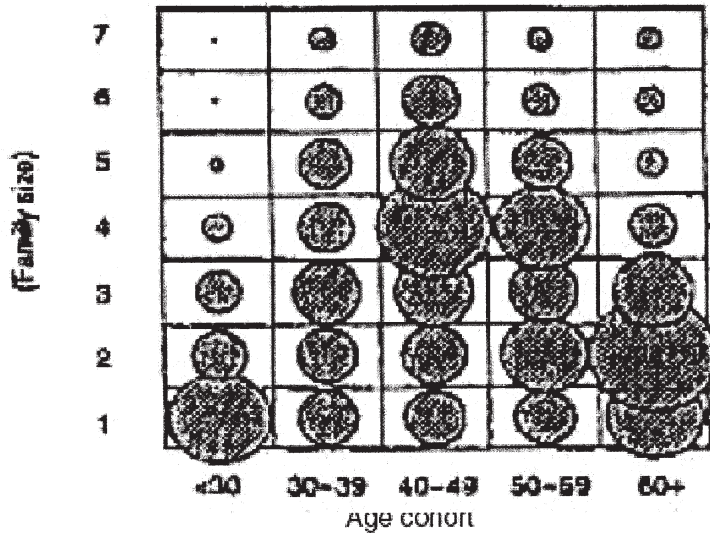


Figure 3: LCM of Japan

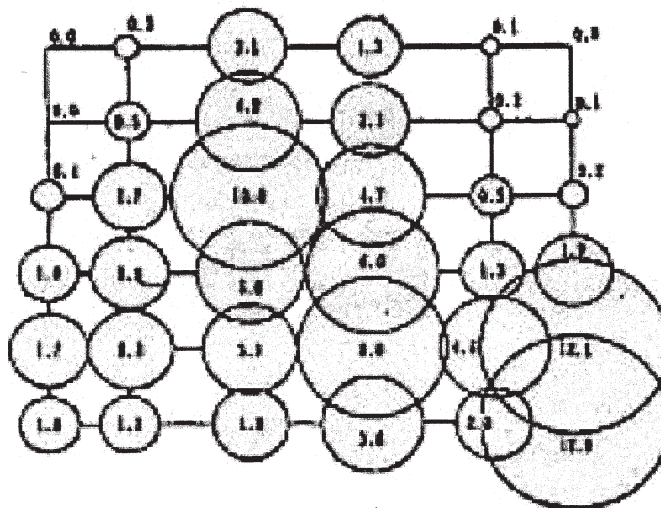
Empirical Cases - LCM Pattern In Developed And Developing Countries

In order to evaluate the use of the LCM in developed and developing countries, Japan and United Kingdom are chosen as cases for developed nations whilst Malaysia and Philippines are chosen as cases for developing countries.



Source: Housing and Land Survey, Japan, 1993

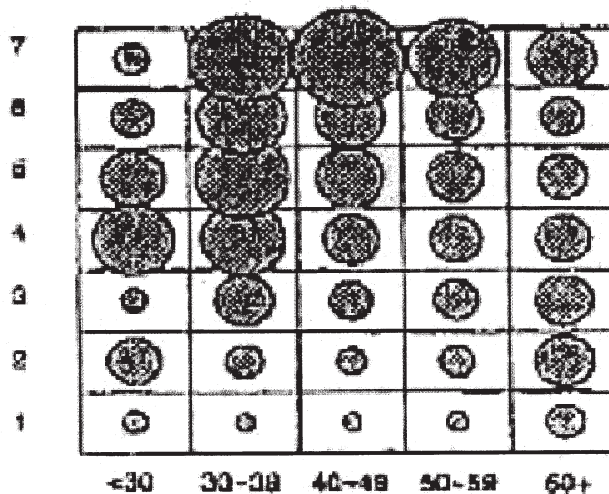
Figure 4a: Japan LCM year 1993



Source: General Household Survey, London, 1991

Figure 4b: UK LCM year 1991

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Source: Census of Population and Housing, Philippines, 1990

Figure 4c: Philippines LCM year 1990

Figure 4a and Figure 4b of Japan and United Kingdom (UK) has similar LCM pattern, which show smaller household size (4 person and below) and high percentage of elderly people (aging society).

According to 1998 national housing survey, Japan has reached 44 millions households, and its household size has decreased from 4.77 to 2.80 persons per household over the period of 40 years (1958-1998). Figure 5 shows the comparison of household size, dwelling unit and population. On the other hand, with low growth rate of 0.2%, the latest census year 2000 shows a higher percentage of elderly persons (17.3% of elderly persons from the total of 127 millions people), increased 11.6% in the past 40 years period (5.7% of elderly persons in 1960).

Study in UK based on data shows a rapid increase of household as compared with the population. For instance, the population increased in 1961 to 1991 was only 8% as compared to 35% increased in household number. In 1902, the average household size in England and Wales was 4.6 persons; in 1939, 3.5; in 1961, 3.1; and in 1991, 2.5 persons per household.

The single person household has grown from 14% in 1961 to 27% in 1991. Married or cohabiting couples with dependent children formed only 26% of all household

while married or cohabiting households without dependent children formed a larger proportion around 35% of all household in 1989. Another 9% of households consist of single parent with dependent children. The other important demographic changes on housing are the increasing number of elderly persons in the population.

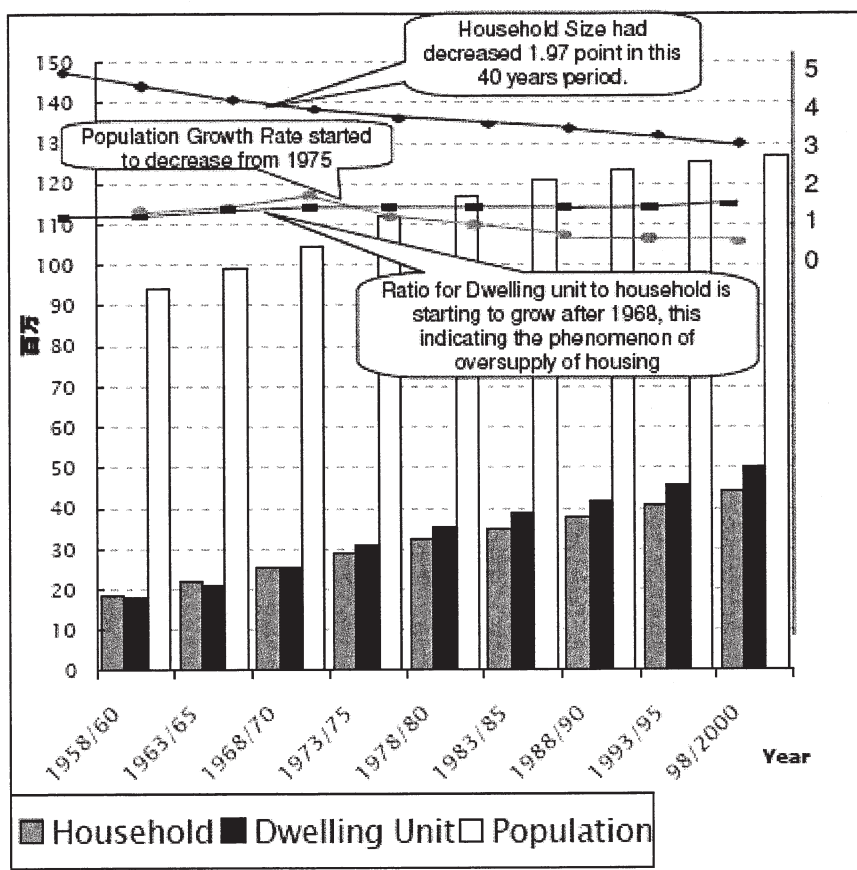


Figure 5: Comparisons on household, dwelling unit and population of Japan

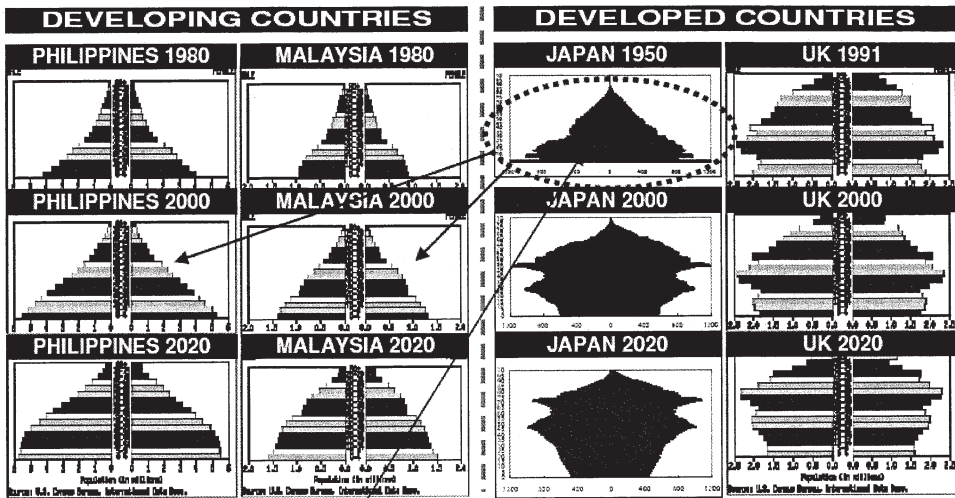
Study of LCM of Philippines shows a high percentage of extended family, young single or couple living in bigger household size of more than 4 persons (refer Figure 4c). Like most developing countries, the population pyramid shows a broad base structure

⁴1990 Census of population and Housing, Philippines. Report no 3: socio-economic and demographic characteristics. National Statistics Office Manila

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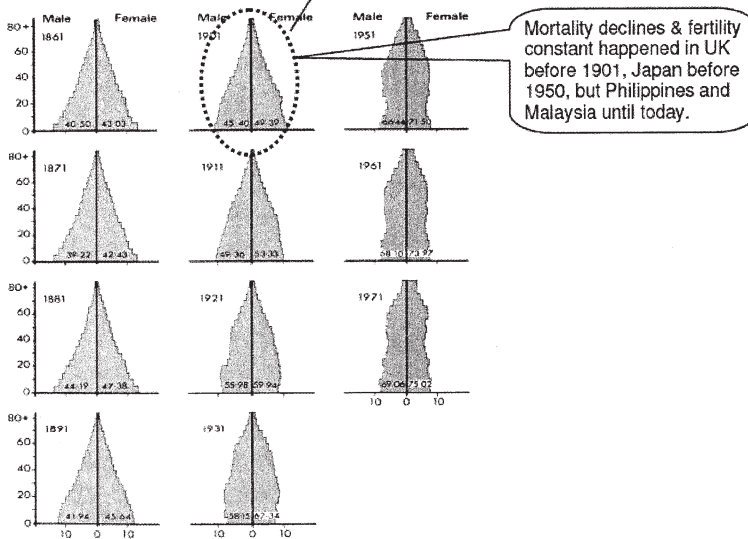
indicating a high percentage of young population (39.5% from total 60.7 millions people). The total number of households in Philippines as of May 1, 1990, was computed at 11.4 millions⁴ and 5.3 persons per household, 0.3 person lower than the 1980 of 5.6 persons (Malaysia was 4.52 persons in 2000, 4.92 in 1991, and 5.22 in 1980 census). This moderate decrease in household size has contributed by the break-up of extended family; couple bearing fewer children; and increase in single person household.

LCM shows a similar pattern in developed countries and probably this trend will also appear in developing countries, such as Philippines and Malaysia. The demographic trend of housing needs in developed countries may provide insight to the understanding of LCM of the developing countries in a kind of “catching up” structure (refer Figure 6a, 6b & 7).



Source: U.S. Bureau, Japan National Institute of Population and Social Security Research

Figure 6a: Population pyramid changes in developing and developed countries



Source: Woods (1979)

Figure 6b: UK population pyramid changes, 1861-1971

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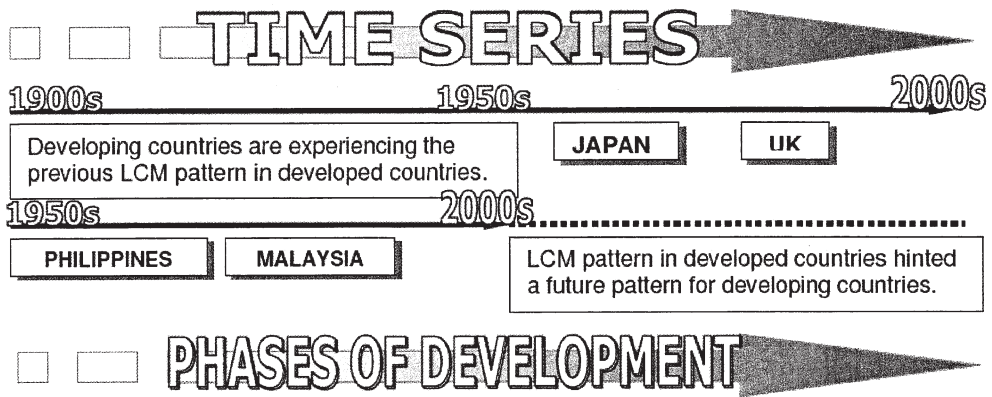


Figure 7:

“Catching up” relationship of developing countries towards developed countries.

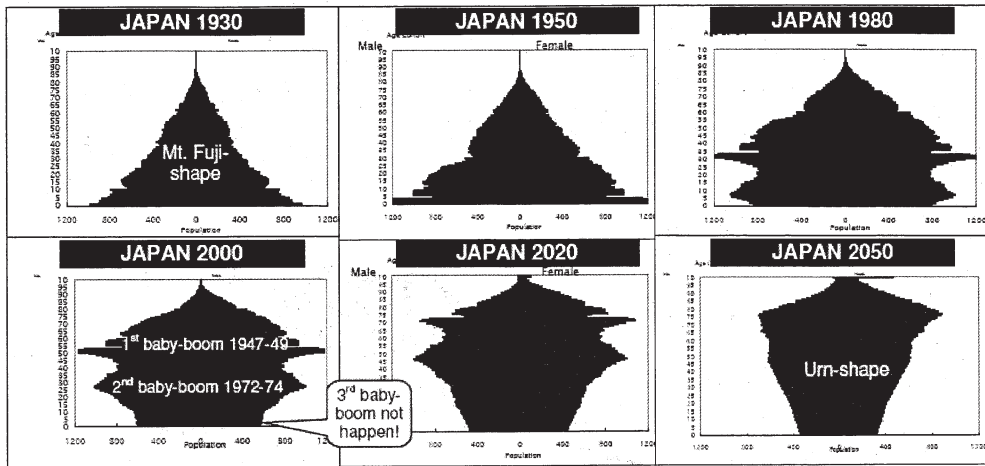
The Demographic Issues in Japan

Two pressing demographic issues facing modern Japan are aging society and declining birth rate. Currently, the population pyramid appears uneven at the older age bracket, because of the fast-paced fluctuation in the past fertility rates - that is, the rapid increase in the number of live birth from 1947 to 1949 (first baby-boom) and the sharp decline in live birth from 1950 to 1957 (baby bust) (refer figure 8). About twenty five years later, the second generation of first baby-boomer has created the second generation of baby boom. However, due to economic factor and late married age, the third baby boom was not happened in the latest census year 2000.

Aging Society

The population pyramid in the year 2000 consists of the first baby-boomer generation at the beginning of the 50s, and the second baby-boomer generation at the end of the 20s. In the 2020 pyramid, the first baby-boomers will be at the end of the 70s, and the second baby-boomers at the beginning of the 50s. It can therefore be concluded that the aging of society toward 2020 is centered on the first baby-boomer generation. On the other hand, the rise in the aging standard around 2050 is the result of interaction among the aging of the second baby-boomer generation and the downsizing of the

population per generation. Hence the population pyramid in Japan has transformed from the pre-war shape of Mt. Fuji to the recent shape of a temple bell, and finally to an urn-shape in the future (refer figure 8).



Source: National Institute of Population and Social Security Research (internet source)

Figure 8: Japan Population Pyramid

Declining Birth Rate

Declining birth rate is another social issue in Japan (refer figure 10). As compared to other developed countries, Japan's birth rate in 1996 was lower than USA and just slightly higher than Germany⁵ (refer table 1). Some scholars argued that this "unhealthy" phenomenon was mainly caused by the rise of the unmarried population (Ueno 1998) (refer figure 9) and economic factors (Yashiro 1998). Other possible explanations are late marriages, high educational expenditures, housing costs, women's higher education and increased participation in the workforce, and a change in cultural values.

Figure 10 shows that during 1949 to 1954, birth rate was dramatically declined from 4.4% to 2.4% per annum. This phenomenon was partly due to fast growing

⁵<http://www.ipss.go.jp/index-e.html> - National Institute of population and Social Research

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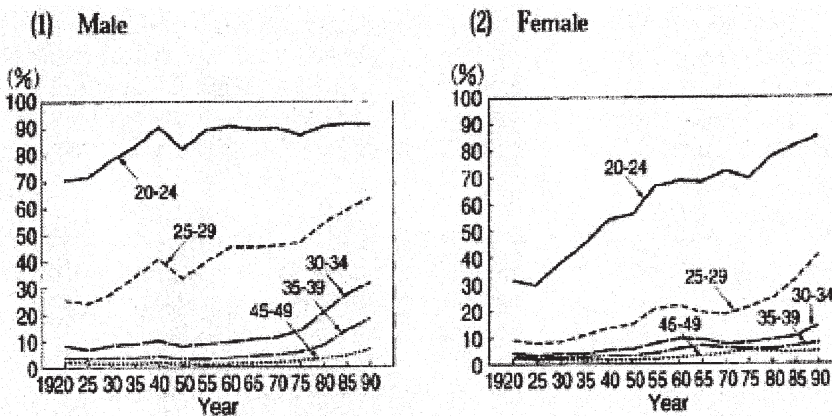
economy and family planning and reproductive health program, which propagated by one of the great woman in Japan history, late Madam Shidzue Kato (1897-2001)⁶. Furthermore, in 1952, the Ministry of Health and Welfare took concrete steps to promote family planning through the Eugenic Protection Consultation Centres.

Table 1: Birth rate in Developed Countries

Country	昭 45 1970	昭 50 1975	昭 55 1980	昭 60 1985	平 2 1990	平 6 1994	平 7 1995	平 8 1996
Japan	2.13	1.91	1.75	1.76	1.54	1.5	1.42	1.43
USA	2.46	1.8	1.84	1.84	2.08U	2.04	2.02	2.04 S
France	2.47	1.96	1.99	1.83	1.78	1.65E	1.70E	1.72E
Germany	2.01	1.45	1.46	1.3	1.45E	1.24	1.25E	1.32
Italy	...	2.14	1.61	...	1.36E	1.22 E	1.19	...
Sweden	1.94	1.78	1.68	1.74	2.13	1.88	1.74E	1.61

Source: Ueno 1998

Figure 9: Trends in the percentage of never-married by age and sex



Source: National Institute of Population and Social Security Research
(internet source in Japanese)

⁶Late Madam Kato was the ex-president of International Planned Parenthood Federation. Her contribution in promoting reproductive health and family planning in Japan and other developing countries is highly recognized by Japanese society. Please refer to http://www.ippf.org/newsinfo/shidzue_kato/

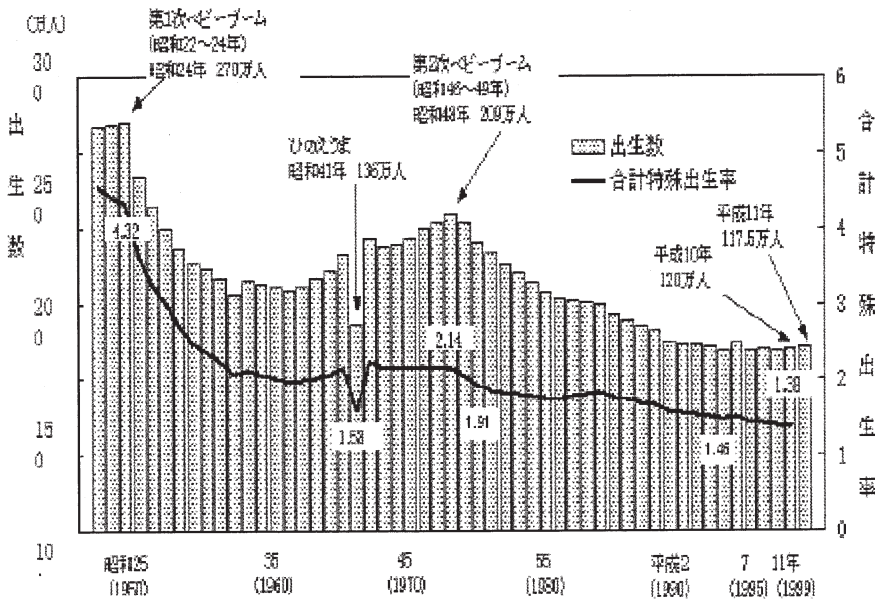


Figure 10: Decreasing birth rate

The Japanese government and economic circles experienced a “1.57 shock” in 1989. The Total Fertility Rate in fiscal year 1989 was reported to be 1.57, slightly below the lowest rate recorded (1.58), in 1966, the year of *hinoe-uma*, which arrives once every sixty years according to the Chinese calendar from ancient times. Believing in the folklore that girls born in this year would grow to gnaw their husbands to death, many couples tend to avoid having a child in 1966. As the birth rates immediately before and after this year were much higher, it is almost certain that the low birth rate in 1966 was intentional. It is surprising that as late as the 1960s, young Japanese couples were still influenced by an age-old superstition. However, the low birth rate in 1989 was a shock because there was no such reason to avoid childbirth in that year.

Population Census and Housing Survey in Japan

According to census record, the first national census was carried out in year 1920 (refer figure 11). Due to culture of ‘calculating mind’ and high awareness of the statistical importance, census was carried out in 5 years interval instead of 10 years⁷. This strong

⁷In developed countries, most of the census cases including European and Americans, were carried out in 10 years intervals.

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backup of statistical population data makes it easier to analyse the household structure and pattern of today's Japanese society. The other factor, which should be noted here, is the culture of 'cooperation and law abiding' in Japanese society. With this cultural background, census was carried out easily and with high reliability.

There are two types of census, namely the main census and sub-census. The main census is based on the whole population of Japan, whilst, the sub-census focus only on 10 percent of the population by randomly sampling in order to reduce expenditure and manpower. This idea of different types of census is a good example for other country to follow because it will help us to have a better forecasting result.

The World War II ended in 1945. Japan was temporary ruled by United States of America until year 1950. During this period, most of the major urban areas, such as Tokyo, Hiroshima, Nagasaki, Kyoto and other metropolitan areas were almost ruined and homeless problem was serious. No census was being carried out in year 1945. However, due to the eagerness of Japanese society, another substituted census was successfully done two years later, 1947.

Besides population census, household data is collected separately in housing survey since year 1948. However, due to some technical problems in this post-war period such as war damage of urban areas, lack of human resources, growing stage of economy and technology and others, the reliability of 1948 and 1953 survey was low. As a result, only the survey in year 1963 was considered as the first complete survey for the whole nation of Japan.

Since the census of population is comprehensive, the housing survey was carried out in five years interval where are the random sampling of 10 percent population was used. Furthermore, one will notice that the year of census and survey is different in intervals of 3 years. This happened because of the lack in human resource and coordination problem in the National Statistic Bureau.

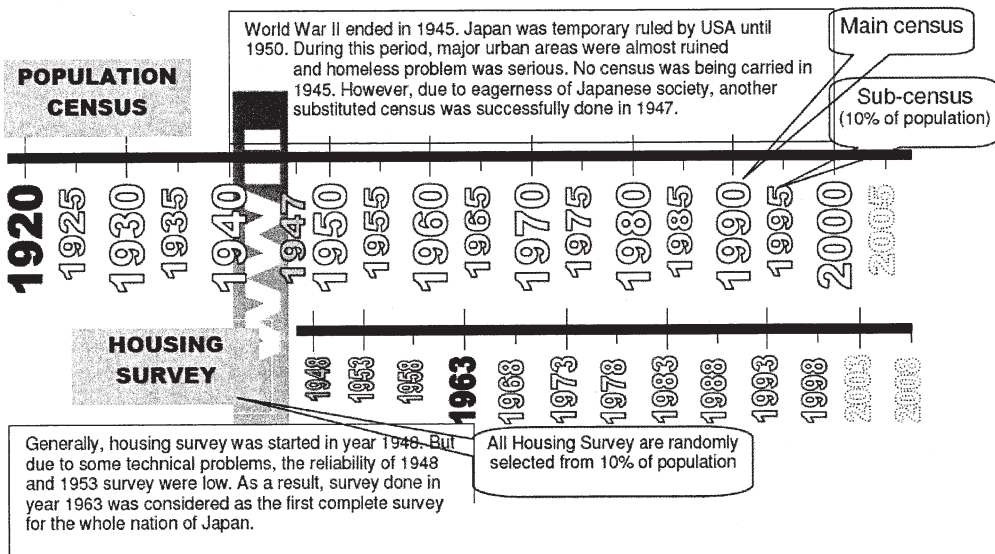


Figure 11: Japan population census and housing survey history

Method F Calculation Used in the Housing Projection

There are five (5) main stages involve in the projection, Cohort Rate calculation, Main Earner Rate calculation, Main Earner Rate by age series calculation, LCM time series change analysis and its projection to the future. The process is summarised as below:

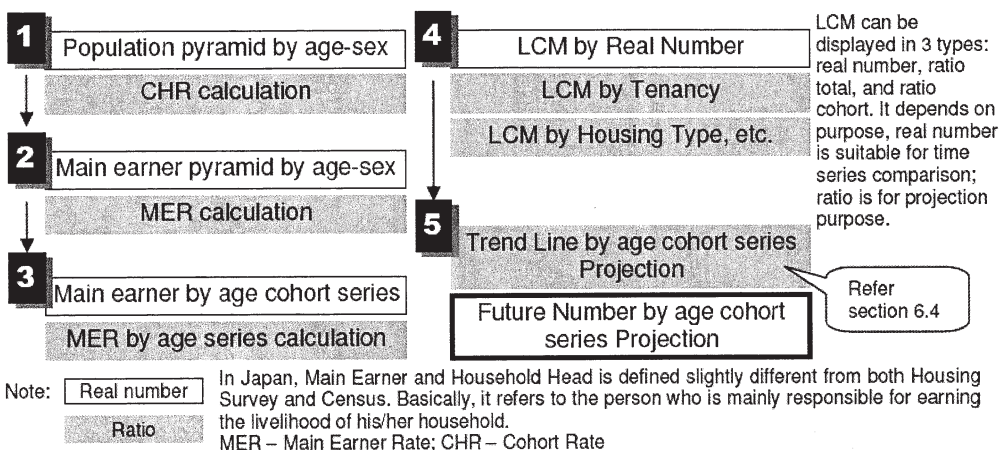


Figure 13a: LCM time series analysis and projection process

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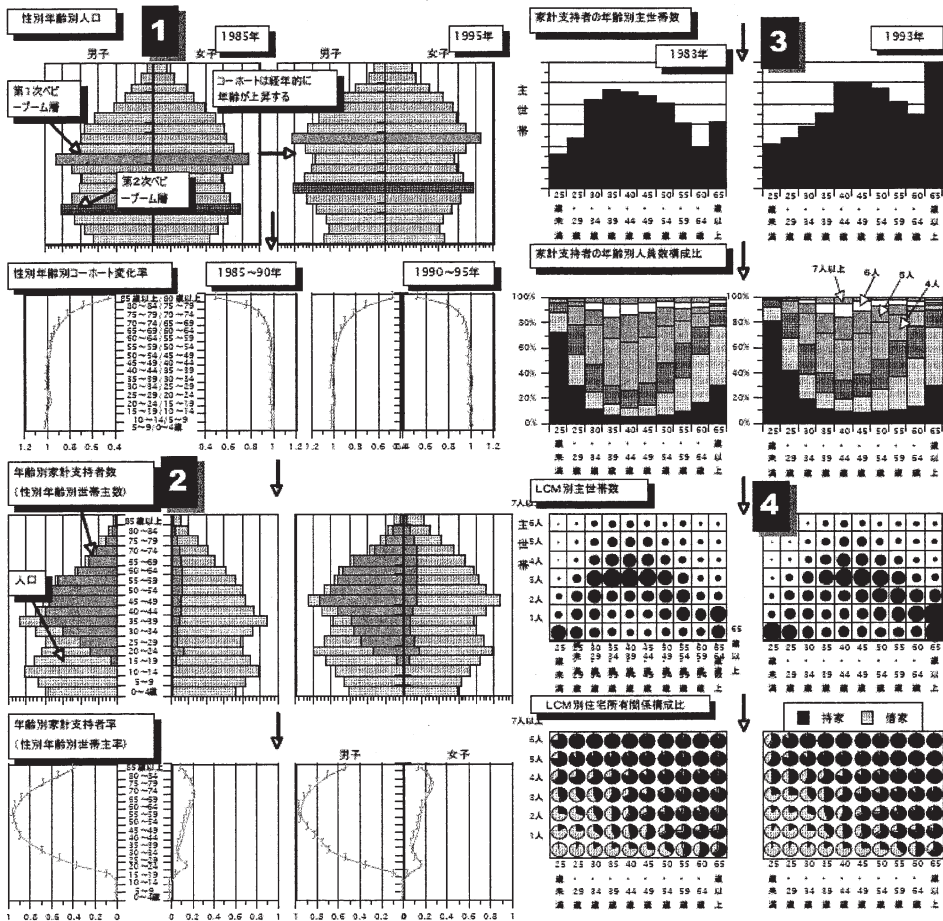


Figure 13b: Examples of LCM time series analysis (Source: Tani, 1998 in Japanese)

Basically, there are two (2) methods in projection, one is by using time series data, and second is by using ratio instead of real number. One of the weakness of using real number is that it changes fast from time to time and one will find that ratio is more constant and it is easier to detect its pattern of change.

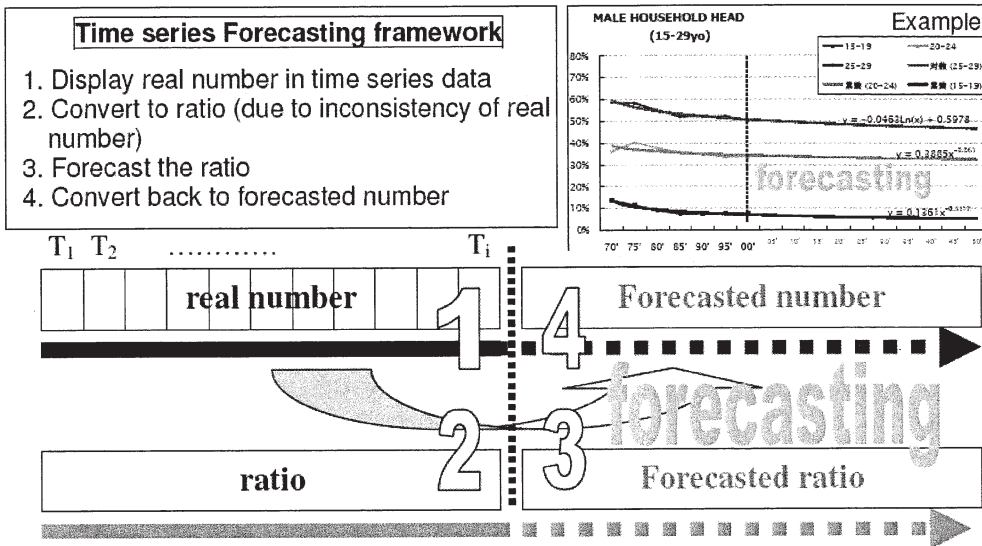


Figure 14: Time series projection framework

In time series projection framework, four (4) steps are involved. Firstly, display and calculate real numbers in time series format. In this case, the longer the time period displayed, the better and more precise of forecasting the future pattern. Secondly, convert the real numbers into ratio format. Normally, ratio format will show a more consistent and stable pattern of data. Thirdly, forecast the ratio according to the existing pattern (see example in figure 14). According to Prof. Miyake, “Forecasting is an art like music, a pattern of ‘harmonious rhythm’ exists in any time series data”. Therefore, by calculating the existing trend line (according to its formula), one can forecast the future trend by simply extending the current trend line. Finally, convert back the forecasted ratio to number.

Figure 15 shows three (3) steps involved in forecasting housing needs by using LCM, namely, population projection by cohort rate method, household projection, and housing needs projection (related to housing demands projection).

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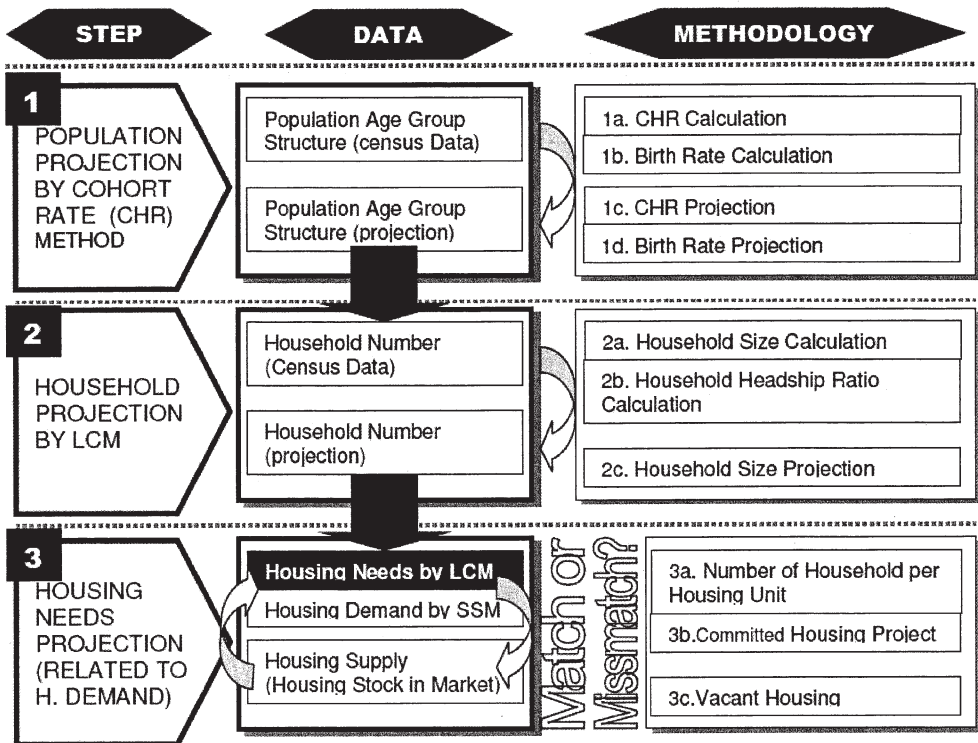


Figure 15: Projection framework

Population Projection by Cohort Rate (CHR) Method

To begin with the forecast of housing needs, one has to calculate the number of population. In this case, the method of CHR, is adopted to justify the increasing or decreasing number of each age cohort (normally 5 years interval). The calculation is shown as below:

$$CHR = \frac{(P_{t+5}) T}{(P_t) T-5}$$

Example,

$$CHR = \frac{\text{Year 2000 (20-24)}}{\text{Year 1995 (15-19)}}$$

Where,

- T – calendar year
- T - 5 – 5 years before calendar year T
- P_t – number of population in calendar year T
- P_{t+5} – number of population in calendar year T + 5

In the case of population changes, it is influenced by two factors, which are social changes (property, employment opportunity etc.) and demographic changes (birth, death, mortality rate). If CHR is equal to 1, meaning that there is no change happened in these 5 years; if CHR is equal to less than 1, meaning that there is a declining number of population (normally happened in elder age cohort and rural area – natural death or out migration); and if CHR is equal to more than 1, meaning that there is an increasing number of population (normally happened in active age cohort 20-39 years old – in migration) (refer figure 13b).

Besides CHR, birth rate is another factor, which has to be considered in assessing population changes. Normally, one can easily get the birth rate data from population census.

Household Projection by LCM

By tabulation of the household data in LCM time series format, the changes of household formation can easily be seen. First of all, household size is calculated according to each 5 years age cohort. Assumption was made that each household needs one (1) housing unit. Therefore, household headship ratio will be calculated to determine the percentage of headship in each age cohort. Projection of housing needs can be carried out based on changing household size in the future.

Housing Needs Projection (match or mismatch to housing supply)

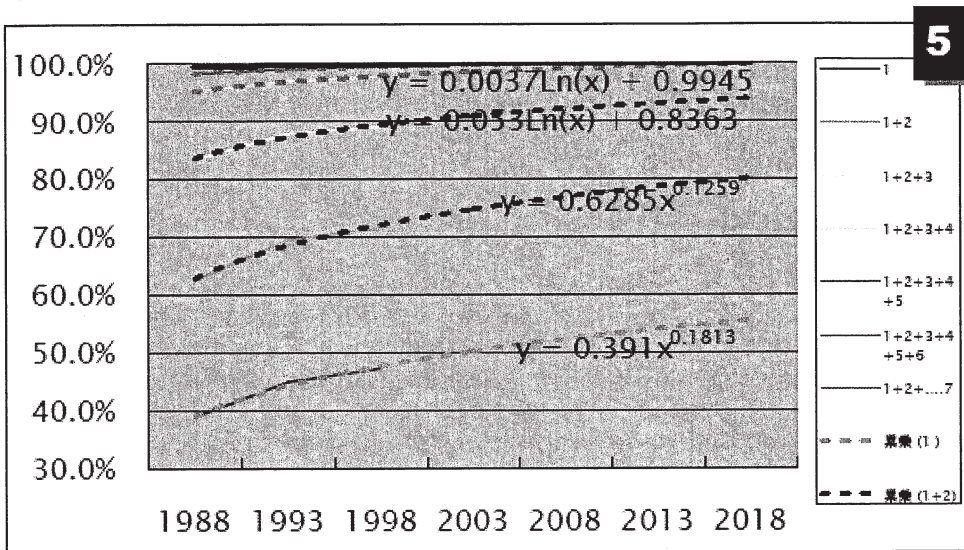
Household changes appeared in LCM are important for the estimation of future needs of housing sub markets. According to Watkins (2001), housing sub markets are too complex to be described by unitary market, its dimensions are determined by both spatial and structural factors simultaneously. The spatial factor refers to location, and structural refers to types or cost of housing. On the supply side, by calculating the committed housing projects and vacant housing in the market, the phenomenon of match or mismatch can be easily determined. Many scholars argue that housing needs does not actually reflect the real demand of housing. To complement LCM method, Social Status Matrix (SSM) can be used as a supportive method to assess housing demand. In general, SSM emphasizes on the real income or affordability of household.

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The age groups in SSM uses the same intervals as in LCM but only change the axis of household size to monthly income range for examples as less than RM500, 500-999, 1000-1999, 2000-2999, 3000-3999, 4000-4999, and more than RM5000. Again, SSM is also a 12x7 matrix of monthly income cross against age groups. (For Malaysian cases, refer to Yee 2002, Lim 2001, Ho 1994).

Trend Line Projection

The final step of projection in LCM time series analysis is trend line by age cohort series projection. The trend line chart is constructed separately by each age cohort, namely less than 25 years old, 25-29 years old etc. In figure 16, an example of 25-29 years old trend line in Japan, shows a consistent pattern of the past, current and future trend. The future forecasted number of each group of household size could be easily calculated by the trend line formula. To construct a forecasted LCM (namely the axis of household size and age cohort), one has to change the forecasted household size number to household number by age cohort. The forecasted population could be obtained from Statistic Department or by calculating its CHR (refer to 6.1).



note: HH – household

Population =HH Size X HH Number

Figure 16: Example of Trend Line Projection: 25-29 years old, Japan

CONCLUDING REMARKS

Since different countries have different demographic and housing conditions and level of development, it is important to consider the following aspects in the LCM analysis:

The Number of Cells in a LCM Matrix

In LCM, the number of cells of household size and age cohort depend on details available in the census data and analysis purpose. It may not be the same for example in Japan it is in 12x7 matrix, 6x6 matrix in the case of UK (refer figure 4b), 5x7 matrix in the case of Philippines case (refer figure 4c) or other combination.

Population Calculation

Population is influenced by both demographic and social factors, therefore, two (2) different ways of calculation should be applied respectively, namely by Cohort Factor Method (social > natural factor) or Cohort Rate Method (natural > social factor). For example, in Japan, before 1980s, population growth was mainly caused by social factors such as migration, urbanization and other demographic factors but in 2000s, natural factors such as low fertility rate (economic and late married factors), longer life span (due to technology advancement in medical treatment and healthy food) are the main factors of population growth. In such case, the Method of Cohort Factor is suitable for the period before 1980s but Cohort Rate method is more suitable for projecting the future population of modern Japan.

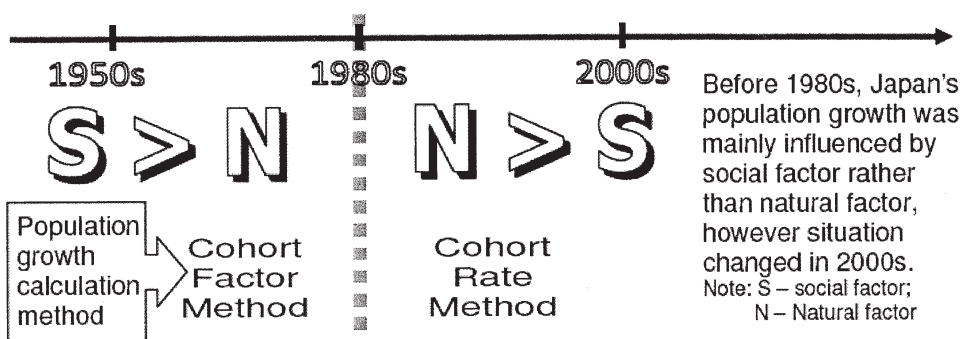


Figure 17: Population growth calculation method in Japan.

From the above analysis, LCM shows a pattern of household formation by different age group, and by understanding its changes and needs, local authority can effectively

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provide and facilitate the housing supply in market. Thus, it helps to reduce the mismatch of housing supply and optimize the utilization of vacant land for other purposes, such as commercial or industrial use. Local authorities in developing countries may explore the use of LCM in analyzing the future housing needs and demand with more quantifiable variables and justification. This method requires more detail population census and housing survey.

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