Alternative Scenarios in Forecasting Demographic Variables: The Case of Indonesia

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Abstract. *Studies on population dynamic have revealed that as the trends and patterns of demographic variables have changed the distribution shapes may also change. In fertility, for example, the decline in total fertility rates (TFR) may be followed by the shifting in the age of childbearing which in turn distorting the shape of fertility rates. Despite these facts, however, most forecasting done in developing countries has traditionally assumed the constant patterns of demographic variables, whereas the levels have changed (e.g. TFR and IMR). This study attempts to fill this gap by contributing an alternative scenario in forecasting demographic variables. Using multiple data sources (census and surveys), assumptions for forecasting was constructed by incorporating variation in the age profile as well as in the level of demographic components. Demographic models, which include the models of demographic schedules and Heligman-Pollard, were applied. This study demonstrated how it is possible, using limited data that available in Indonesia and in many developing countries, to construct alternative 'dynamic' scenarios. It has been done so by applying some advanced demographic methods to Indonesia data, and draw evidence from other, similar countries. An alternative 'dynamic' scenario was implemented by using the changes of levels and patterns of demographic parameters over the forecasting period.*

Keyword: Fertility, mortality, migration, forecasting, dynamics, developing countries, Taiwan, Indonesia.

1. INTRODUCTION

One of the important steps in population forecasting is making reasonable and consistent assumptions about the future course of demographic variables (i.e. fertility, mortality, and migration). In many developing countries, which often have limited data sources, population forecasting has a long tradition of explicitly specifying alternative future variants in terms of scenario analysis. Four criteria of the scenarios as defined in Lutz (1995) have been identified in the past forecasting. *First*, more emphasis is put on the "if-then" nature of the calculation as opposed to the likely prediction. *Second*, a scenario is utilized to make all assumptions explicit. *Third*, three components of change (i.e. fertility, mortality, and migration) are addressed separately. *Fourth*, the scenario developed typically looks at a somewhat larger number of scenarios (e.g. more than one or two). Scenarios have been regarded as strategies for dealing with the uncertainty in forecasting the future population. In addition, it is frequently presumed that the levels of demographic variables have changed (i.e. expressed in terms of total fertility rate and infant mortality rate or life expectancy) but the shapes of the age profiles are not assumed to change.

This present paper attempts to develop scenarios for population forecasting that accommodate the dynamics of age patterns of demographic variables, particularly in the context of developing countries. The dynamics of age patterns are considered since these patterns tend to vary vis-à-vis overall levels and depend on the circumstances in each country or region. This paper starts with an overview of background in constructing the assumptions for future demographic trends and the age-specific patterns (Section 2). Section 3 the dynamic scenarios by using Indonesia as an example are elaborated. Lastly, section 4 concludes the paper with remarks and recommendations.

2. TRENDS AND PATTERNS OF DEMOGRAPHIC VARIABLES

Many studies have extensively discussed demographic change in both developed and developing countries as a reflection of a demographic transition phase with different stages in every country. It is not surprising therefore theoretical frameworks that relate to demographic transitions (e.g., Notenstein (1945) focused on fertility and mortality, and Zelinsky (1971) and Skeldon (1997) focused on population mobility) are customarily considered in assessing and formulating the trends of demographic variables.

Naturally, the transitions in three main demographic variables—fertility, mortality, and migration—have contributed to the population dynamics at both global and regional levels. The changes in fertility can be partially explained by an increase in schooling levels, a higher female labor participation rate coupled with postponements in marriage and births, and increasing use of contraceptives. Mortality changes and the concomitant changes in life expectancy could be attributed to advancements in health care systems, particularly use of health care services and improvements in the quality of life. In response to the changes in fertility and mortality and the concomitant developments in the country's economic situation, migration patterns may also change considerably which is triggering a high level of population mobility.

The changes in basic demographic variables will eventually change the age structure of population. Population with high fertility and mortality usually has population pyramid with a broad bottom (young age) and a narrow top (old age), while population with low fertility and mortality usually has a relatively more flat and wide type of pyramid, characterized with high percentage of older population. In between, there may be population changes characterized with narrowing base, swelling young productive age, and slowly increasing number of older population. In a circle, the change in age structure will certainly affect demographic behavior (i.e. birth, death and migration) since these variables are very age-specific. Hence, considerations of age patterns of the demographic variables are also inevitable in order to understand the demographic changes in these limited data sources countries. This section reviews common assumptions that have frequently been considered in forecasting fertility, mortality and migration variables in the context of developing countries.

2.1 FERTILITY RATES

In most cases, the demographic conditions of a country would be assumed to shift from high fertility and mortality rates to the low fertility and mortality rates, as concluded in the demographic transition theory (Notenstein, 1945). The transition of fertility has also been described in terms of the decline in TFR (Coale, 1973). It represents a shift from a high TFR to replacement level (net reproduction rate equals 1 and TFR is usually around 2.1 children per woman), and even to below the replacement level.

These days, developed countries and NICs (newly industrializing countries) are already in the last stage of the fertility transition. Yet, the transition stages show a discrepancy among developing countries. Furthermore, Demeny (1997) pointed out that a different problem has emerged at the end of transition. Rather than lower population growth rate at the end of transition, some countries may have somehow high population growth. Some factors involving socio-economic and political circumstances may be responsible for the failure of their vital rates to decline, together with the pace and speed of their initial stage. Bongaarts and Watkins (1996), in the study on fertility transition in 69 developing countries, observed that there is no fixed threshold of development for the onset of the fertility transition. In other words, socio-economic development is not all the time regarded as a driving force behind the transition.

Even as the total fertility rate is assumed to decline, the shape of the age distribution of fertility rates is primarily assumed to remain constant over the forecasting periods, even if the periods considered are sometimes very long (e.g. 30 to 50 years). In the long term, however, it is believed that the distribution of fertility rates by age may change considerably as a result of changes in fertility behaviors and its determinants, such as the timing of childbearing, the age of first marriage, the concept of partnership, and the contraceptive use practices.

In many developing countries, births are mostly assumed to occur within marriage only. For this reason, the fertility rates are principally collected from ever-married women only and it is assumed that births outside marriage are negligible. Even though, the latter trends of fertility have been offset somewhat by the growing practice of premarital sex and may cause the growing numbers of abortion among young and unmarried women (i.e. become pregnant as a result of changing sexual behavior). In other words, age at first marriage is strongly related to the timing of the onset of sexual relations and childbearing in the developing countries. As the age at first marriage has increased, the age at first birth will also increase. Furthermore, the change in the institution of marriage from traditional practices (i.e. where parents are involved) to more modern forms (i.e. couples finding and courting their partner of choice) has contributed to the rising of age at marriage (Hull, 1994). This trend is likely to continue in the future as the education level of women increases and yield to the increase in female labor force participation.

The invariant in shape of the age distributions of fertility rates simply means there is no *tempo* effect or distortion due to changes in the mean age of childbearing. In actual fact, using data from the World Fertility Survey and the Demographic and Health Survey, Bongaarts (1999) revealed that fertility trends in many developing countries are likely to be distorted by changes in the timing of childbearing (the presence of tempo effect). In other words, as the tempo effects are present then the age distribution of fertility rates may shift to higher or lower ages. Using Taiwanese and Singaporean fertility data for the period 1960-1999, Muhidin (2002) demonstrates that the age distribution of fertility rates in both countries has changed in accordance with the significant decline in TFR together with the shift of the peak age of fertility rates. In the past, women age group 25-29 years dominated the high proportion of fertility rates. In the recent period, however, the peak age distribution of fertility rates tended to shift to age group 30-34 years. Using Indonesia as a study case, Muhidin (2002) also demonstrates that the invariance assumptions for the age-patterns can also be due to the fact that the fertility rates are estimated by the indirect methods and clustered into five-year age groups.

2.2 Mortality Rates

The mortality transition is commonly referred to as an epidemiological transition, which is partly a health transition. It relates to the changes in disease patterns, mortality patterns, and the conditions associated with these changes (Bobadilla et al., 1993, cited in Hilderink, 2000). For developing countries, where the data on adult mortality are difficult to obtain, the infant mortality rate (IMR) has been widely used as one of the indicators of mortality transition. Mortality is presumed to have finished its transition when it has achieved the last stage so-called hard rock phase, with the IMR below 30.

The mortality transition by using the IMR as its indicator goes back to the concept of infant mortality classes initiated by Bourgeois-Pichat (1952). He distinguished two classes of infant mortality based on the causes of deaths, i.e. endogenous and exogenous infant mortality rates. Later, D'Souza (cited in Utomo and Iskandar, 1986:94) translated those two classes into three broad classes of causes of deaths. These are infectious origin (*soft rock*) similar to endogenous IMR, non-infectious origins (*hard rock*) similar to exogenous IMR, and a combination between infectious and non-infectious origins (*intermediate rock*). Soft rock is indicated by an IMR higher than 100 deaths per thousand births. Hard rock is indicated by an IMR below 30, and intermediate rock is indicated by an IMR between 30 and 100.

Likewise the process of fertility transition, the transition of mortality has also related with the changes in socio-economic circumstances of the country. An improvement in socio-economic resources resulting in more effective use of health facilities and improvement in medical technologies will lead to a decrease in the IMR. Moreover, the advancement of educational level of women (i.e. mother) has supported the decline in infant mortality.

Studies, using the Demographic and Health Survey (DHS) data for various countries, have demonstrated that the more educated the mother the lower the IMR.

As far as adult mortality is concerned, the adult mortality rates are often estimated indirectly on the basis of infant and child mortality through a set of model life tables such as the regional life tables developed by Coale and Demeny (1966). From this procedure, the mortality transition is occasionally elaborated in terms of life expectancy at birth, which is based on the levels of IMR. In accordance with the declining IMR, life expectancy is presumed to increase over time.

Nevertheless, the issue of appropriateness of the model life tables to estimate the mortality patterns is often a matter of debate. Using the same model life tables (e.g. the West model) over the forecasting periods implies similar patterns of mortality by age group over time. It also means that differences between life expectancy for males and females remain constant. In the West model, for example, the life expectancy for females is always higher than that for males. In other words, the mortality patterns in a country may differ from the established model regional patterns, such as the West model. Coale and Demeny also stated (UN, Manual IV, 1973:36) that there is little foundation for confidence that the relationship between mortality rates at different ages in the West model holds closely in a population in Africa, Asia or Latin America. Indeed, the Coale-Demeny life tables were mainly constructed based on mortality histories of developed countries. In the meantime, the characteristics of epidemiological transition in developing countries may not be similar to the transition in the industrialized countries.

The assumption above on adult mortality patterns is even more unrealistic for countries where regional differences are noticeable (e.g. having various cultures and ethnicities) or have a great transformation in the underlying cause of death by age group. Currently, some countries have faced major political and economical uncertainties. Levels of this uncertainty vary among the countries. Many people have died in the accompanying violence and civil war. This particular cause of death may exert a temporary effect but may have a large impact on the age structure of the population since the majority of victims are adults and males. In addition, HIV/AIDS cases have been found among people in developing countries, such as in African and Asian countries. Initially, HIV/AIDS was linked to homosexuals. However, cases in many countries have shown that the infection is already spread out among heterosexuals and even trough prenatal transmission (i.e. to the infant child). Using a particular life tables, therefore, may be inadequate to capture these realities. It may be that the level of IMR may remain constant but adult mortality may increase.

2.3 Migration Rates

Unlike the assumptions made for fertility and mortality rates, which is always from high rate to low rate and heavily influenced by its past trends, the assumptions applied to the migration variable is different. As argued by Skeldon (1997), there is no such pattern in migration, that there is a tendency from high or low rates to low or high rates of migration. Yet, there exists "patterned regularities" in migration, so-called mobility transition. Yet, the migration or mobility transition is more complex than the one on fertility and mortality. Zelinsky (1971), for example, presented five stages of mobility transition as inspired by Ravenstein's work on migration laws[1]. Further, considering the fact that in many parts of the developing countries have emphasized the importance of non-permanent forms of mobility or circulation, Skeldon (1990) modified the earlier mobility transition from five transition stages into seven stages.

Nonetheless, there have been many descriptive (qualitative) studies about escalating population mobility in the developing countries in terms of permanent (*long-term*) and non-permanent (*short-term*) mobility. Censuses and surveys as main data sources often provided information on migration in terms of permanent and provincial migrants. These are categorized as status data, comparing the residence status of a person at two points in time (i.e. at the census time and 5 years prior to the census). Because of the nature of the data set, migration analysis is then limited to the analysis of proportion of migrants, instead of the rates of migration. Net internal migration is more commonly considered than origin-destination migration for measuring migration trends. The forecasting at sub-national and national levels are occasionally made separately and then these are subjected to a series of corrections to account for the net effect of interregional migration in order to maintain consistency with the national figures. Another method used started from the national population forecasting and disaggregated the result according to assumed share of the total population in each of its regions. Moreover, international migration is frequently ignored, since the forecasting generally assumed that most countries in the developing world still belong to the category 'closed population country.'

In accordance with little attention to migration trends, the age patterns of migration have principally been assumed insignificant. Actually, many researches have pointed out that there is a selectivity of migration with respect to age. Young adults generally show the highest migration rates and young teenagers the lowest. The regularities in migration schedules in various countries motivated Rogers and Castro (1981) to summarize the regularities by means of mathematical expressions called "model migration schedules" and to derive 'typical' migration profiles. The age profile of migration starts with relatively high levels during early childhood; the levels decrease in the teenage age and then increase until they reach a high peak at age 20-24. Later on, they decrease again to the age of retirement. Occasionally a post-labor force component appears, showing either a bell-shaped curve with a retirement peak at age 65 for instance, or an upward slope that increases monotonically to the last age. Thus, the migration age profile is divided into four components: pre-labor forces ages, labor force ages, post-labor force ages, and a constant curve.

Based on the fact above on the complexity in dealing with the migration variable, therefore, it is no wonder that little attention has been given to migration trends and its patterns in the context of developing countries. In the last decades, however, these countries have been continuously experiencing social and economic changes. These changes and extension of development in those countries will eventually influence the changes in the level and patterns of population mobility. For example, the development in the country's education system and labor market as a result of new development in human capital may affect the dynamics of population mobility due to education and employment. In addition, the increase in the volume of population mobility may be a logical consequence of the improvement in transportation means and networks, and increase in economic activities. Increased in economic activities is particularly seen in urban areas where the informal sector economy provides job access for migrants. Therefore, it would seem plausible that in the near future, population mobility in these countries will become even more significant. Both internal and international movement will become more complex in the overall spatial patterning.

3. ALTERNATIVE SCENARIOS FOR INDONESIAN FORECASTING

In view of the facts mentioned above together with the past trends of demographic variables, the scenarios developed in this section attempt to evaluate the effect of demographic changes on the future population. Initially, three main demographic components (i.e. fertility, mortality, and migration) are considered. The dynamics scenarios for population forecasting are examined not only in terms of the total level, but also in terms of the shape of the age patterns. However, in this paper we will limit our discussion to the dynamics scenarios for fertility and mortality variables. With regard to migration, there are still many factors that (as far as the author knows) difficult to solve. Among others are how to justify the relations among migration level, regional direction, and age patterns over time. Studies on this particular issue are often ended up by presuming that the age-specific migration rates will change proportionally as the level of migration changes and the direction remain similar, which is somehow no longer to be called as a dynamic assumption.

As an example to develop dynamic scenario, we will apply to Indonesian population forecasting, which consists of 12 main clustered regions (see Figure 1). A discussion of the assumptions is applied to fertility in section 3.1, and mortality assumptions in section 3.2.

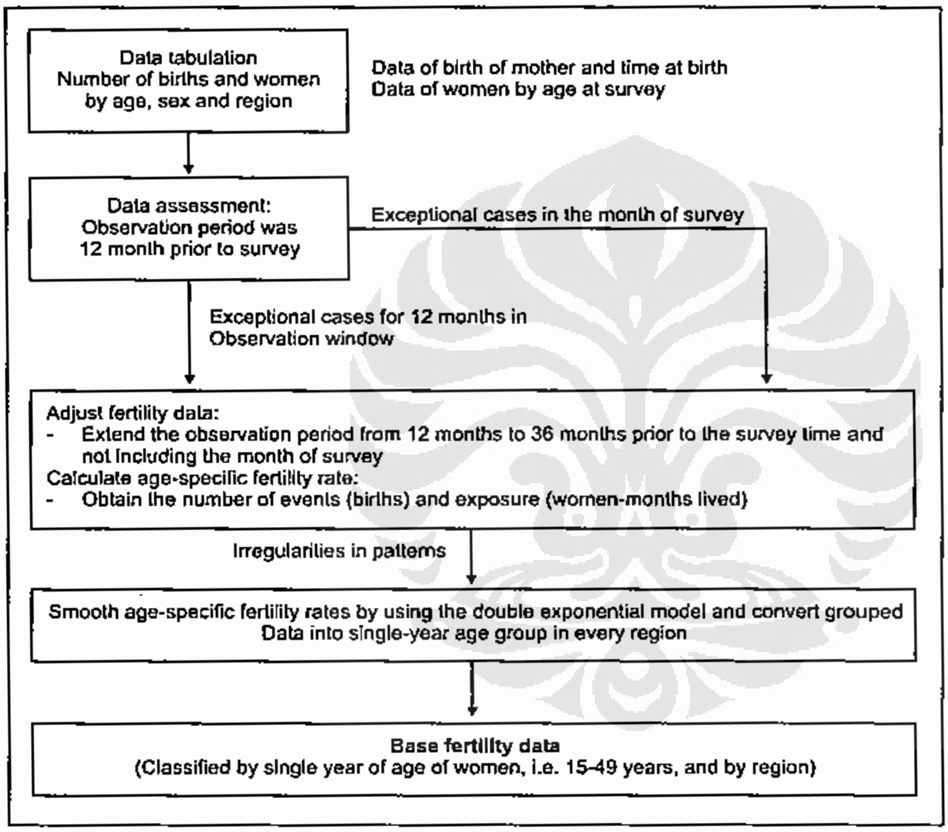
Figure 1
MAP OF INDONESIA

Notes:			
	1. Northern Sumatra	5. Central Java	9. Southeast-West Timor
	2. Southern Sumatra	6. Yogyakarta	10. Kalimantan/Borneo
	3. Jakarta	7. East Java	11. Sulawesi/Celebes
	4. West Java	8. Bali	12. Maluku/Papua

3.1 Fertility Assumptions

In order to estimate the future fertility rates in Indonesia, we will use the TFR by following its past trends. The past trends are derived from the 1971, 1980, 1990 national population censuses and the 1991, 1994 and 1997 Indonesia Demographic and Health Survey (IDHS). From the census data, the fertility levels were obtained by using indirect methods, particularly the Own Children Method, while from the IDHS data, fertility levels were estimated directly. These selected data sources reveal that the patterns of TFR declined during past periods are neither linear nor exponential, but logistic.

Diagram 1
SUMMARY OF ESTIMATION AND CONSTRUCTION OF BASE FERTILITY DATA



The second stage is to decompose the TFR into the age-specific fertility rate (ASFR). The forecasted TFR is decomposed the ASFR by using the proportion of ASFR. Two assumptions are applied for comparing the constant and dynamics scenarios. *First*, the proportion of ASFR during the forecasting period (e.g. 1990-2020) is assumed to remain constant at the proportion observed in the initial period, says 1990. The changes of TFR are then observed in the absence of changes in the timing of childbearing (i.e. quantum effect). The initial regional proportions of ASFR are derived from the 1994 Indonesia DHS. Detailed discussion on constructing the fertility base data can be found in Muhidin (2002). Diagram 1 summarizes the procedure for estimating and constructing the base fertility data for the IDHS data.

Table 1 shows the constant proportions of ASFR for Jakarta at the beginning and at the end of the forecasting period, respectively, in 1990 and 2020. The assumption of constant proportions has generally been applied in the past forecasting.

Second, the proportion of ASFR is assumed to change over the forecasting period. In other words, tempo effects are present in Indonesian fertility. In relation with the decline of regional TFR, the mean age of childbearing is assumed to change over time. Discussion on previous sections has supported this assumption. Based on various studies, the mean age of marriage among Indonesian women has increased during the last three decades. It also means that the mean age of childbearing may increase, since most Indonesian women tend to have their first birth after marriage. The growth of contraceptive prevalence among married women has also increased. In addition the duration of breastfeeding in Indonesia is relatively long irrespective of the mother's background. In addition, pregnancy termination (abortion) is more prevalent in Indonesia today.

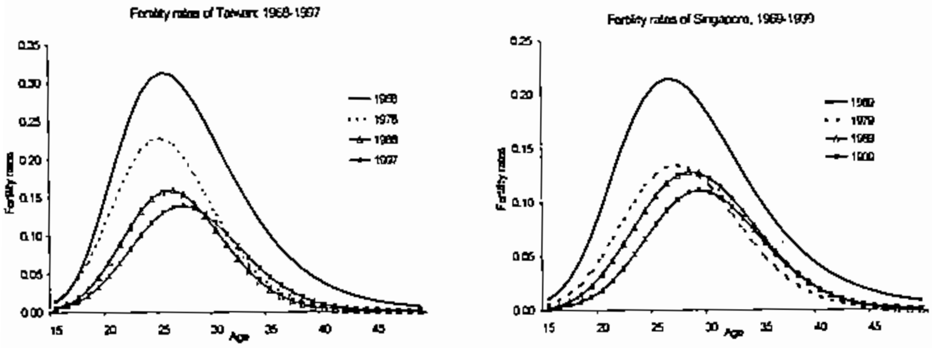
Ideally, past patterns are utilized to determine the patterns of future change. Nonetheless, data on the past proportions of age of regional Indonesian fertility are not available. In such circumstances, the past experience of other countries will have to suffice as a guideline to envisage the future change. In this case, fertility data from Taiwan and Singapore are utilized for reasons of location of these countries (Asian countries) and their relatively complete and reliable vital registration system. Bongaarts (1999) also used Taiwanese registration data to analyze the presence of tempo effects in an Asian country.

Table 1
AGE SPECIFIC FERTILITY RATES (ASFR) FOR JAKARTA USING CONSTANT PROPORTION SCENARIO

Age Group	*ASFR IDHS1994*	*Proportion (%)*	*ASFR 1990*	*ASFR 2020*
15	0.0032	0.16	0.0037	0.0026
16	0.0063	0.32	0.0071	0.0051
17	0.0119	0.60	0.0135	0.0097
18	0.0210	1.06	0.0236	0.0170
19	0.0335	1.70	0.0377	0.0272
20	0.0489	2.47	0.0551	0.0397
...	...	...	...	...
...	...	...	...	...
45	0.0159	0.80	0.0179	0.0129
46	0.0137	0.69	0.0155	0.0112
47	0.0119	0.60	0.0134	0.0096
48	0.0103	0.52	0.0116	0.0083
49	0.0089	0.45	0.0100	0.0072
15-19	0.0152	3.85	0.0171	0.0123
20-24	0.0808	20.47	0.0911	0.0657
25-29	0.1196	30.27	0.1348	0.0972
30-34	0.0910	23.04	0.1025	0.0740
35-39	0.0510	12.92	0.0575	0.0415
40-44	0.0252	6.39	0.0285	0.0205
45-49	0.0121	3.07	0.0137	0.0099
TFR	1.97		2.23	1.61

In fact, both *Taiwan Demographic Fact book* and *Yearbook of Statistics Singapore*, as the data sources, provided fertility data in terms of five-year age groups. Assuming that the fertility rates among women in any five-year age groups are similar, then the single year of fertility rates could be obtained. For example, the fertility rates for women aged 15 years would be same as the fertility rates for women in age group 15-19 years. Since the double exponential model has shown promise in previous studies, particularly on Indonesian fertility data, the model is utilized for fitting the fertility data of Taiwan and Singapore. Figure 2 shows the age-specific fertility rates in these countries during the period 1968-1999. It shows that the dynamics of age patterns are evidenced in Taiwan and Singapore.

Figure 2
AGE-SPECIFIC FERTILITY RATES (ASFR) IN TAIWAN AND SINGAPORE, 1968-1999



With regarding to the proportion of ASFR, some studies (e.g., Brass, 1980 and Kim, 1986) have pointed out that the cumulative distribution function of the ASFR closely follows a Gompertz curve. The cumulated values under the curve are equal to one. The Gompertz relational model measures the deviation of observed fertility to a standard chosen. The Gompertz function is as follows:

$$F(x) = \exp(-\exp(-\lambda(x-\mu))) \qquad (1)$$

the density function is then:

$$f(x) = \lambda \exp((-\lambda(x-\mu) - \exp(-\lambda(x-\mu))) \qquad (2)$$

where x is age of women, λ is a shape parameter that relates with a narrow spread of the age distribution, and μ is the mean of the childbearing ages. The density function of the Gompertz model is a double exponential function similar to that used by Coale-McNeil (1972) for first marriages and Rogers and Castro (1981) for migration schedules. However, the density function here has one less parameter than the more general double-exponential function used for first marriage and migration schedule.

For the Gompertz function $F(x)$, there exists a linearizing transformation $Y(x)$, where $Y(x) = -\ln(-\ln F(x)) = \lambda(x-\mu)$. Thus, the transformations of several Gompertz curves are linear to each other. If we relate the transform $Y(x)$ to a standard transform $Y_s(x)$, where $Y(x) = A + B.Y_S(x)$, the parameters A and B demonstrate that:

$$A = \lambda(\mu_s - \mu) \text{ and } B = \lambda / \lambda_s \quad (3)$$

where λ_s and μ_s are usually λ and μ in the standard function presented by Brass (1980). Using this model, the proportions of ASFR from Taiwan and Singapore during the observed periods are then estimated. However, the standard function utilized is related with the function in the initial period, instead of the standard function presented by Brass.

Figure 3 shows the trends of parameters A and B estimated from Taiwanese and Singaporean fertility data. The same trends are then applied to determine the proportion of ASFR for Indonesian data. Using parameters A and B and parameters λ_s and μ_s from the base data, the proportion of ASFR for every region are predicted. The ASFR during the forecasting period are then calculated by multiplying the predicted proportion of ASFR and the projected level of TFR. For the regions that currently have TFR equal to or below 3.0, the proportion of ASFR will follow the fertility pattern of Singapore. These are the provinces in Java and Bali, except West Java. On the other hand, for the regions that currently have TFR larger than 3.0, the fertility patterns from Taiwan will be used.

Figure 3
PARAMETERS FROM FERTILITY PATTERNS IN SINGAPORE AND TAIWAN

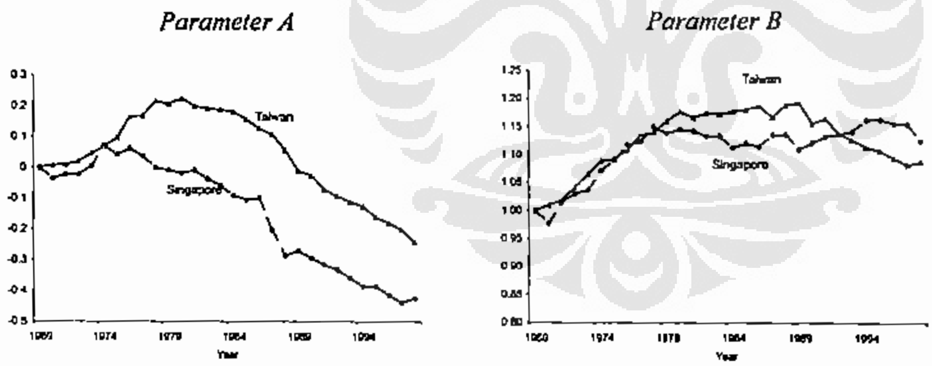
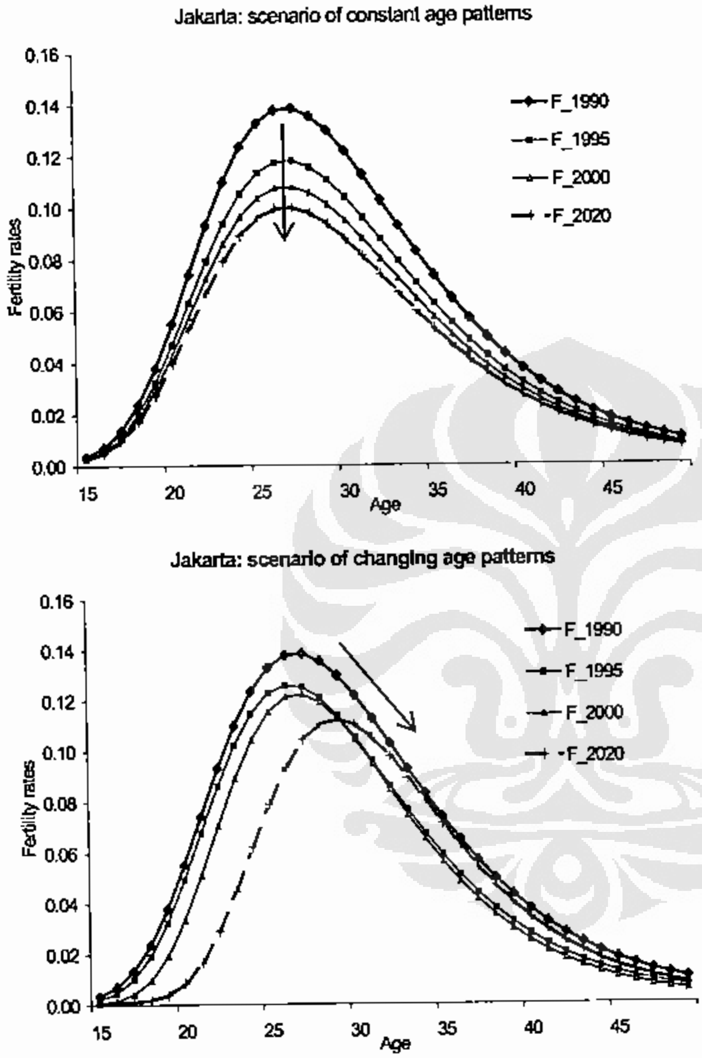


Figure 4 shows the fertility patterns for Jakarta by using the scenario of constant age patterns and the scenario of changing age patterns. Under the constant scenario, the mean age of childbearing among women in Jakarta remain at age 27 years. On the other hand, under the changing age patterns scenario, the mean age of childbearing changes from 27 years in 1990 to 29 years in 2020.

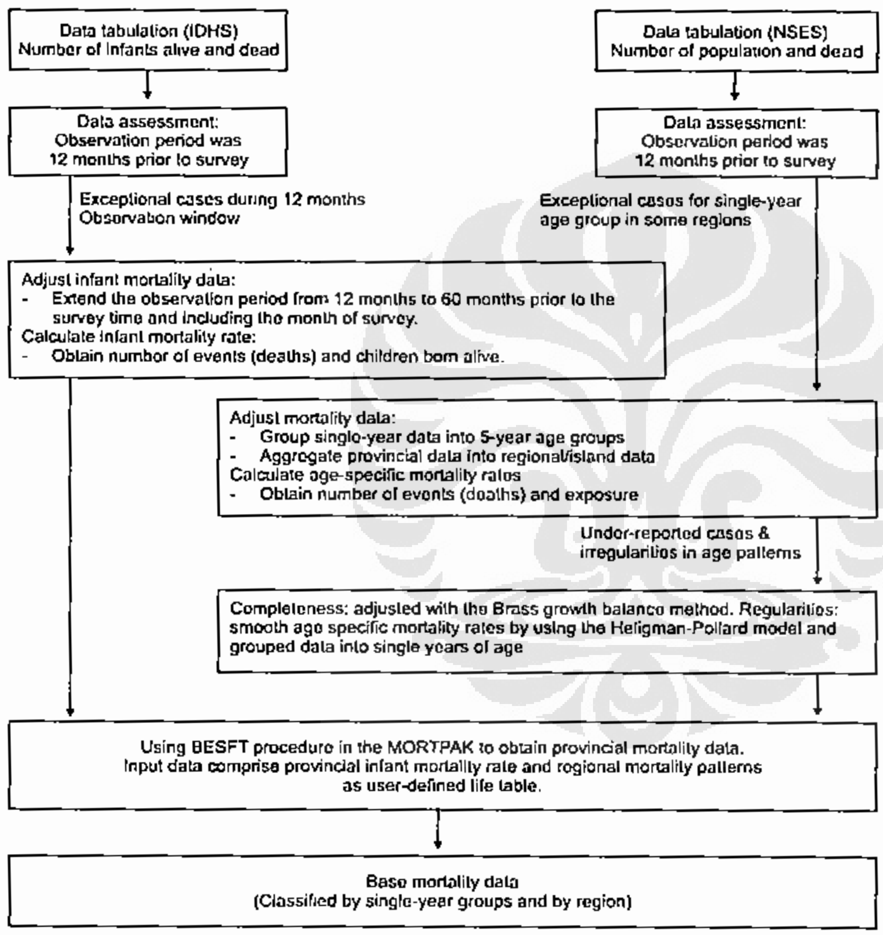
Figure 4
PROJECTED AGE-SPECIFIC FERTILITY RATES BY DIFFERENT SCENARIOS, JAKARTA 1990-2020



3.2 Mortality Assumptions

Trends of complete mortality data, such as provided in the life table, in Indonesia and in many developing countries are frequently not available. Therefore, the past trends of infant mortality rates (IMR) are still utilized to estimate future trends of mortality. Values of the IMR from the past periods are observed from the 1971, 1980, 1990 censuses, and the 1991, 1994 and 1997 IDHS.

Diagram 2
SUMMARY OF ESTIMATION AND CONSTRUCTION OF BASE MORTALITY DATA

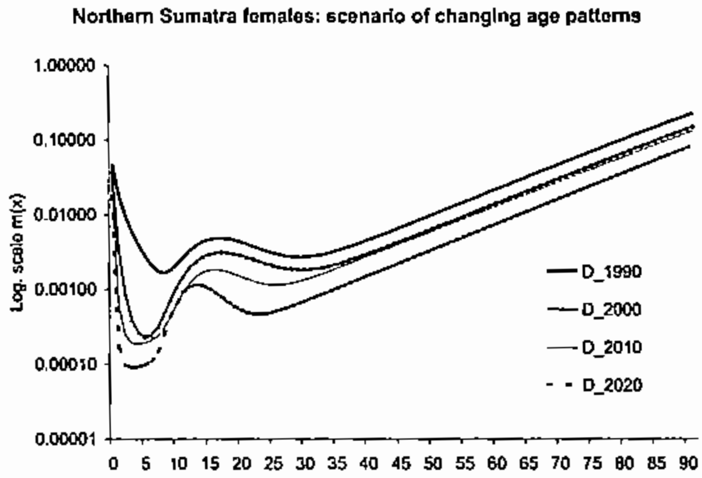


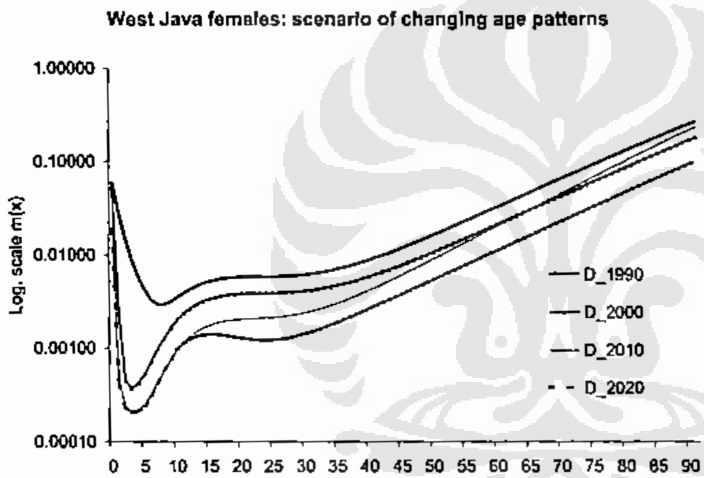
Instead of using the model life table of Coale-Demeny (1966), however, we utilize the recent Indonesian life tables for estimating adult mortality. The Indonesian life tables were constructed by using data from the National Social Economic Survey/NSES (see detailed discussion in Muhidin, 2002).

Diagram 2 summarizes the procedure for estimating and constructing the base mortality data. It starts with the estimation of IMR from the IDHS and the construction of adult mortality patterns from the NSES data. Some adjustments were made to the data estimated based on the assessment results. Then, the IMR estimated and the mortality patterns constructed were utilized for constructing mortality base data at the national and regional levels. Standard procedures of BESTFT and UNABR provided in the MORTPAK package are applied. The BESTFT procedure is utilized for fitting the IMR estimated to the regional mortality patterns (i.e. as a user-defined model life tables). The UNABR procedure is operated to produce the mortality schedule model for Indonesian regions.

Similar with the developed scenarios for fertility, two scenarios are also distinguished in forecasting mortality. *First*, it is assumed that the age profile of mortality remains identical to that observed in 1990. Complete mortality rates for all ages are estimated by fitting a single death rate (IMR) to the user-defined model life tables estimated. Similarly, the IMR forecasted can be fitted to the base regional mortality profiles in order to obtain similar mortality profiles during the forecasting periods. Figure 5 shows the mortality profiles for females in Northern Sumatra and West Java under the conditions of constant age mortality patterns in the period 1990-2020.

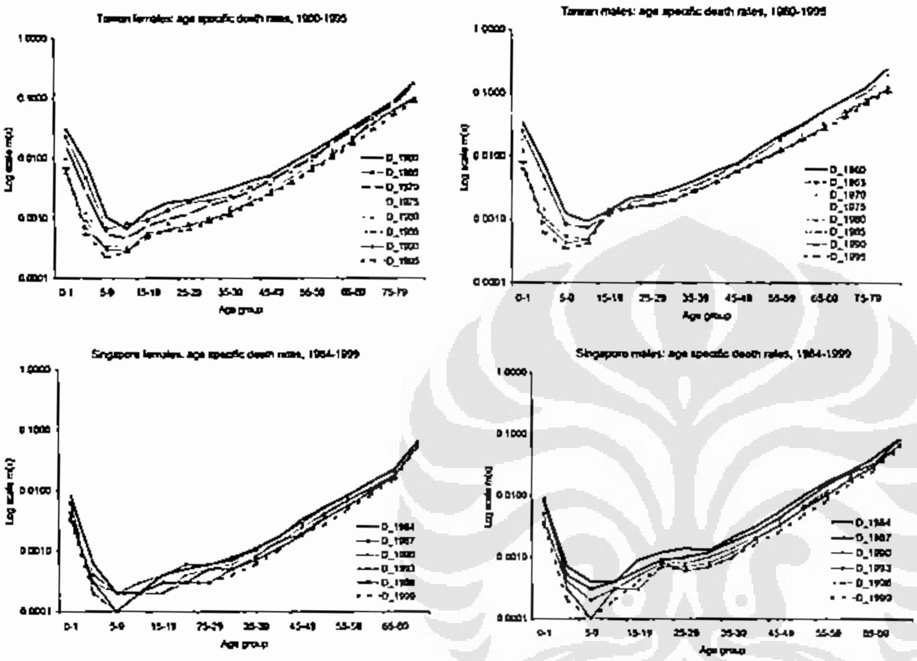
Figure 5
REGIONAL MORTALITY PATTERNS FOR THE SCENARIO OF CONSTANT AGE PATTERNS, 1990-2020





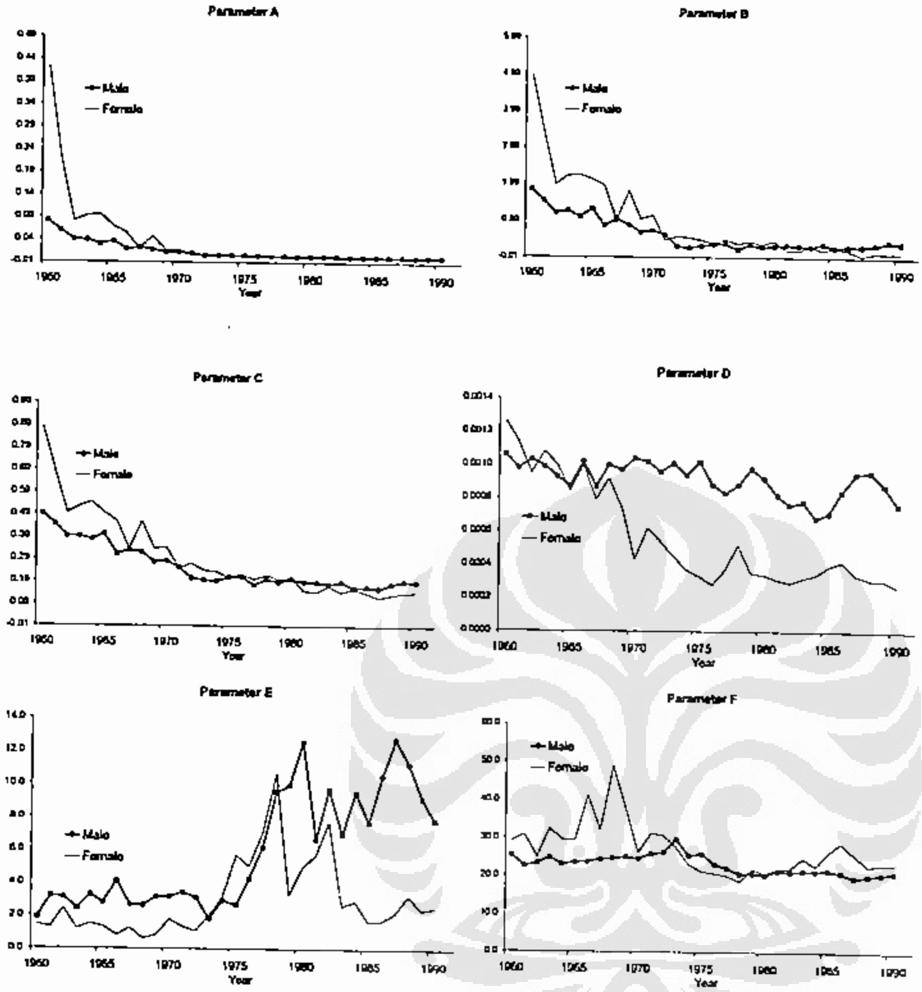
Second, the age patterns of mortality are assumed to change over the forecasting period. Since data on the past trends of Indonesian mortality are not available, the experiences from other countries, in this case are Singapore and Taiwan, are again utilized. The same reason as for fertility forecasting is applied to explain why mortality data from these countries are utilized. Figure 6 demonstrates that both referred countries have experienced the dynamics of mortality patterns during the last few decades. With regard to the mortality trends, however, Taiwanese mortality data (for males and females) are available for a longer period (i.e. 35 years, between 1960 and 1995), while Singaporean mortality data are available for shorter periods (i.e. 15 years, between 1988 and 1990). Since the forecasting period considered here is 30 years (i.e. between 1990 and 2020), thus mortality patterns from Taiwan data are utilized further in this research.

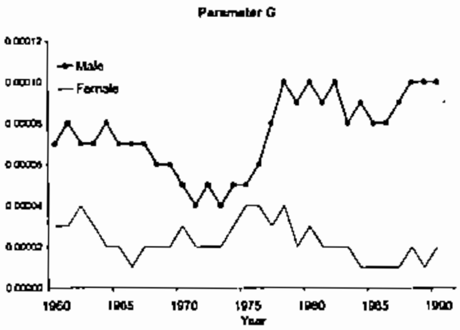
Figure 6
MORTALITY PATTERNS FOR TAIWAN (1960-1995) AND SINGAPORE (1984-1999)

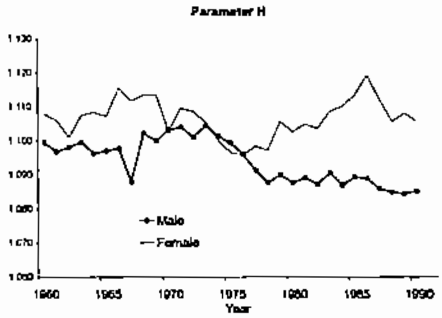


In order to see the changes in Taiwanese mortality patterns, the parameters from the Heligman-Pollard model are considered. The parameters obtained are presented in Figure 7. Although the dynamics of these parameters are related with the socio-economic situation in that country, these parameters can be used for mortality forecasting in Indonesia. Adopting these trends and using the parameters of Indonesian regional mortality models as base data, the parameters of regional mortality models are predicted for the forecasting period. The projected parameters are then utilized to calculate future age-specific death rates.

Figure 7
PARAMETERS OF THE HELIGMAN-POLLARD MODEL FOR MORTALITY IN TAIWAN, 1960-1990







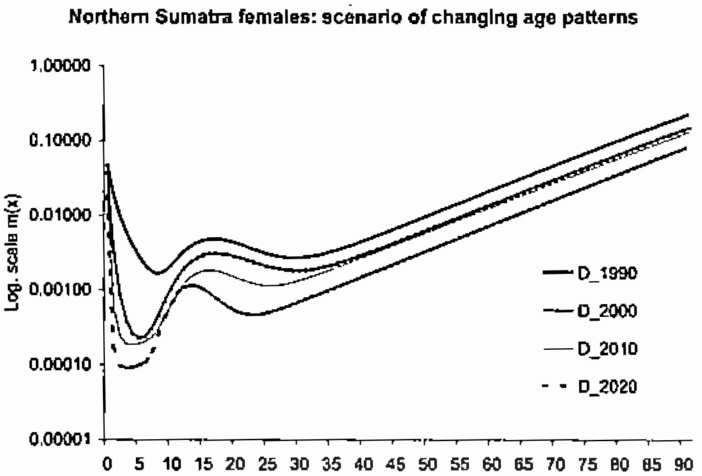
Special attention should be paid to the first three parameters (*A, B* and *C*). These parameters and parameter G determine the infant and child mortality. Since only the IMR values have been projected, it is important to analyze the relationship between IMR and those parameters. These can be expressed as follows:

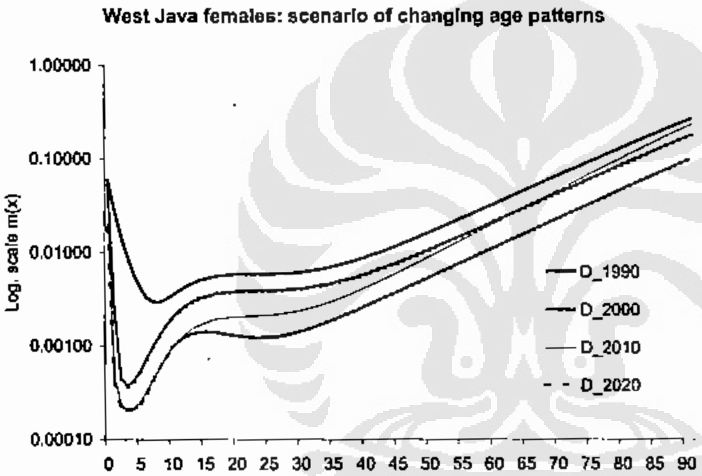
$$IMR = q(0) = A^{(B)^C} + G \quad (4)$$

$$C = \ln\left(\frac{\ln(IMR - G)}{\ln(A)}\right) / \ln(B)$$

Using Taiwanese mortality data, it is observed that these parameters (*A,B,C, G*) have a relationship with the IMR values. The parameters *A* and *B* tend to decrease following the decline in the IMR. On the other hand, the parameter *C* decreases as the IMR increased. The value of parameter G is small and it relatively remains similar at any level of IMR. In this research, the trends of parameters *A, B* and *G* are assumed to follow Taiwanese mortality models. Given these estimated parameters, thus, parameter *C* can be calculated by using equation 4. Figure 8 presents the mortality patterns for females in Northern Sumatra and West Java under the assumption of dynamic age patterns.

Figure 8
REGIONAL MORTALITY UNDER A CHANGING SCENARIO, 1990-2020





4. CONCLUDING REMARKS

In the past, the population forecasting in developing countries was based predominantly on conventional demographic analysis, without adequate consideration of the dynamics of age-specific demographic patterns. One of the reasons is frequently said due to severe data problems. Hence, indirect methods were mostly utilized for estimation the levels of demographic variables. As time goes by, the quantity and quality of demographic data in these countries and others have improved. This situation apparently has encouraged demographers to present more accurate and better information of trends, determinants, and consequences of the population dynamics in the developing world.

This present paper addressed methodological issues related to population forecasting techniques in less developed nations. A dynamic scenario was considered. This approach considered the changes of levels and patterns of demographic parameters over the forecasting period. Using Indonesia as an example, it was demonstrated that the development of dynamic scenarios could be done using data from several sources. The data, however, had their limitations. Though it had historical levels of demographic variables (i.e. from indirect and direct estimations), the data contain hardly any information on historical age-specific patterns. As a result, we had to rely on indirect techniques in this research in order to bridge the gap between data availability and data requirements in various demographic estimations.

In the preparation stage of input data, there were also problems on incomplete data and irregularities, which required some methods to solve these problems. For example, the irregular age pattern problem necessitated the application of model demographic schedules to estimate fertility and mortality patterns. The models of double exponential and Heligman-Pollard were utilized for smoothing the irregular data and constructing the base data, respectively, on age-specific fertility and mortality. The results obtained are utilized as input base data for forecasting purposes. Using the demographic schedules models has made it possible to produce the base input data in terms of single-year period and single-year age groups. Additionally, using the parameters from these models, the dynamics of age patterns of demographic variables were captured.

The scenarios developed in this paper, however, require further modifications. For example, the formulation of accurate assumptions about future demographic parameters could be based on the predictions of future changes in social and economic factors and their association with demographic parameters. In other words, we can continue to develop models to forecast the demographic parameters using socio-economic factors as explanatory variables.

In addition, although fertility variable will be still assumed to be the dominant factor of population change in developing countries, further development on the dynamics scenarios for mortality and even migration, particularly international migration should be essentially continued.

NOTE

1. Two of the migration laws from Ravenstein (1885: 288, cited in Zelinsky, 1971) established the relationship between migration and economic development. First, migration increases in volume as industries and commerce develop and transportation improves. Second, the major causes of migration are economic. This implies that migration is in effect caused by economic development.

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