Population under Harsh Time

- Demographic Response to Short-term Fluctuations and Crisis in the Contemporary Modern Economy

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Abstract

A considerable number of studies on historical and some third world populations have reached a magnificent consensus that both mortality and fertility do respond to economic changes in a surprisingly shared pattern. Such response, however, remains a great deal of controversy, obscure and inconsistency in the secular industrialized countries. The aim of this paper is to explore the association between economic changes and demographic responses in the contemporary modern economy. While there is widespread interest in this subject with particular focus on short-term fluctuations, I further study the impact of severe economic crises, measured by real GDP per capita and unemployment rate, on mortality and fertility in two advanced industrial nations: Sweden 1970-2007 and Japan 1971-2006. Statistical results indicate that the magnitude of such impact on population have been largely mitigated in contrast to the past and not necessarily lethal. There is certain inconsistency across the two countries, and therefore few shared patterns being generalized.

Keywords: Economic fluctuations; Economic crisis; Fertility; Mortality; Demographic response; Sweden; Japan

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1 Introduction

Economic crisis can have a pronounced impact on population in the short-run. For instance, during the great depression in the 1930s, population growth had reached lowest level since the 1880s. Such population loss in crises might be attributable to increase in mortality and declines in fertility (Lee, 1990). There are ample of evidences revealing the adverse effects of economic hardship. Some old studies on historical population provided many commonalities of the demographic responses to economic hardship: marital fertility is negatively and mortality is positively related to grain prices, this is also known as part of the Malthusian theory. However, such responses in the contemporary developed world remain controversial.

One of the most influential writers asserted that real income loss and rising unemployment are strongly associated with mortality increase for virtually all age groups (Brenner, 1983; 1987). Nevertheless, some argued that mortality trend is following an irreversible downturn and the frequency and duration of oscillation around secular trends were reduced to insignificance or disappeared (Palloni and Hill, 1997). Additionally, some studies of mortality trends in Latin America have come to the consensus that economic crisis and structural adjustment typically have not led to an increase in mortality (Palloni, 1989; Bravo, 1997; Hill and Pebley, 1988). Hence, one of the central questions proposed in this study is whether economic crisis would impose magnitude impacts on mortality in the contemporary industrialized countries.

There is also a cloudier regarding the secular fertility response to extreme hardship. A few evidences supported the pro-cyclical response, such as the Dutch famine of 1944-45 which induced the monthly births dropped from 4000 to 1700 mainly due to lowering calories consumption (Stein *et al*., 1975), and "the great leap forward" in China constituted total fertility decline by nearly 3 per woman (Ashton *et al.*, 1984). However, no one has shown that such pro-cyclical response has continued to hold since the 1950s (Lee, 1990). In contrary, a counter-cyclical pattern has been elicited, as the fact that opportunity costs of child bearing has been take into account, its arising while the economic circumstances is favorable and decline otherwise. Therefore, question merit a great consideration is that whether or not economic crisis would still significantly affect the birth rate? If so, it should be pro- or counter-cyclical?

Not only are crises, but also economic fluctuations are likely to have impacts on vital rates, as Lee (1990) claimed that both fertility and mortality respond to economic fluctuations, and many shared patterns of demographic response have been generalized in historical and some third world populations, whereas the patterns in contemporary industrialized countries are still obscure, controversial and inconsistent among different advanced economies. One important regard is that the frequent and sharp fluctuations in the levels and age patterns of mortality have been weakened, and which is an important marker distinguishing the mortality trends in modern world from historical society. On the other hand, along the widening availability of contraceptive methods, fertility rate in well-developed nations has gone through the long-term demographic transitions and reached the late stage, as a result, quite a few countries have been marked as the lowest-low fertility country which, in a large part, contribute to eliminating the frequency and magnitude of oscillations in long-term fertility trend. Thus, the last question remains: is the association between economic

fluctuations and variations in vital rates still significant in the modern economy? Or has it disappeared?

The aim of this paper is to explore not only the association between short-term economic fluctuations and demographic responses, but also the effects of economic crisis on population change in the secular advanced economies. For the former, the investigation is concentrated on the effects of annual differences in economic indicators on fertility and mortality change, and for the latter, two big crises occurred in Sweden and Japan during the 1990s have been set as the point of departure and a time-series study has been conducted on the mortality and fertility response to extreme economic hardship. The entire time span of this study covers the year 1970-2007 for Sweden and 1971-2006 for Japan. Unlike many other studies which generate sub periods to distinguish the crisis episodes, I introduce the categorical variables for the growth rate of real GDP per capita and the dummy variables for extreme high rate of unemployment so as to distinguish the severe crisis episodes.

The paper begins with a review of a few previous studies on demographic responses to economic changes in both historical and contemporary populations. Fruitful background information generates a sophisticated theoretical foundation and raises the reasonable hypothesis. The next section starts with an introduction of the data references, followed by a description of the data series. Chapter 4 clearly explains the methods of detrending and adjustments of variables, the statistical model employed in this study, and the definition of both dependent and explanatory variables. The key important part is the statistical results, interpretations and discussion which are discernable in the fifth chapter. The last, but absolutely not the least, is the conclusion part which summarizes all the findings, generates some assertions, and indicates potential directions for the future research.

2 Background

2.1 Previous Research

Demographic responses to economic changes have been widely studied for both pre- and modern societies. However, the patterns, trends and magnitudes of such responses in both contexts are different. Studies in historical population, and even some less developed third world countries at present, generalized many shared patterns reflecting the existence of short-term association between economy and population (Galloway, 1988; Hammel, 1985; Richards, 1984; Lee, 1981), whereas in contemporary industrialized world, which results are obscure and controversial (Lee, 1990). Furthermore, many findings generated significant inconsistency among different well-developed nations and time spans. Therefore, one of the central questions in this study remains: has the effect of short-term economic fluctuations on the population disappeared, or at least mitigated, in the industrialized world during recent decades, in contrary to the past?

Most studies have particularly concentrated on the short-term demographic-economic fluctuations by examining the lag patterns of demographic responses in great detail, such methodology was developed by Lee (1990) and Galloway (1988) and has been widely used to historical settings. Nonetheless, particularly in the modern context, the

specific focuses on the demographic responses to severe economic crisis, by which is meant that there is sudden and extreme change in economy such as the appearance of extreme high prices and unemployment or low income and GDP grwoth, are rare. A study conducted by Lee (1981) explored the threshold effects of extremely high prices on the historical population of England 1541-1871, in which the explanatory variable (wheat prices) was sub-divided into five categories, ordered through very low to extremely high, the interval between each two categories is one standard deviation, and a non-linear relation was hypothesized that mortality would be particularly badly affected by a run of high prices and which effect would be greater than the sum of effects of comparable but isolated instances of high prices. Although the results revealed a clear association of mortality and prices, a significant threshold effect of extreme high prices was only captured at the contemporaneous year, but afterwards, and a year of extremely high prices which occurred only a few times a century would be merely associated with 19 percent increase in the average annual number of deaths, thus the hypothesized lethal effect was rejected. As such evidence stem from the historical society is insignificant and relevant studies have been rarely conducted for the last decades, it is noteworthy - would severe economic crisis have magnitude influence on contemporary population in the industrialized world?

2.1.1 Economic Crisis and Short-term Fluctuations

The reason that this paper is entitled as "Demographic Response to Short-term Fluctuations and Crisis in the Modern Economy" is that there is a belief that the effects of fluctuation and crisis on the population could vary because of the definitions of the two in nature are substantially different in macroeconomic theory. Therefore, it is worthy to have a brief discussion about the difference between these two scenarios in the economy, especially in the modern context.

There is no robust definition to differentiate economic crisis and short-term fluctuations; most previous studies used variations in prices as a proxy for economic performance, this somewhat confounded the effects of a regular up- and down-swing, and severe downturn in the economy. In order to separate such effects, I define here that the former is referred to a recession and growth within a certain range of deviation – namely economic cycles, the latter, however, is marked by a recession that is prolonged and associated with magnitude drop in real GDP, employment, or abnormal inflation - namely depression.

Economic cycles may trace back in agrarian society which also had a set rhythm of upswings and downswings in production[1]. Similar phenomena could be also discerned in industrial society, for instance, during the second half of the twentieth century, the United States experienced several recessions, but none of them lasted over two years. However the causes of cyclical changes are different. The recessions of 1953 and 1957 were mainly due to adjustments of monetary polices, early 80s recession was attributable to the oil price increase during the 70s, and in 2000s, the causes are more various, such as overheated market (e.g. dot-com bubble), business failure (e.g. accounting scandals), and terrorism attack (e.g. the 9.11 attack).

On the other hand, in the old world, severe crisis is mostly induced by bad weather

[1] Magnusson (2000) argued that the basis of cyclical changes over a single year, and from one to another is formed by changes in climate and variations in annual growth rates.

and deterioration of cultivate condition which constitutes extremely low level of production and high prices. Such non-cyclical evidences can also be found in the modern society. The most severe crisis occurred in the 20th century accounts for the Great Depression initiated by the financial market collapse in the US, the Wall Street Crash of 1929, and quickly spread to the worldwide economies. More harmfully, this crisis lasted for (more than) ten years, started in 1929 and ended at different times for different countries.

All in all, the difference between crisis and fluctuation is obvious. Upswings and downswings within certain range due to economic or business cycles are regarded as normal economic fluctuations. Such cyclical recession occurs rather frequent and shorter, contrarily severe depression is rather prolonged and happens only a few times a century, and therefore usually acts as an outlier in the picture of long-term economic growth.

2.1.2 Demographic Responses

Although demographic consequences of economic changes have been widely discussed for both pre- and modern societies in many researches, the patterns, trends and magnitudes of the response are different. Studies on historical population, and even in some less developed world at present, carried out many strikingly shared patterns reflecting the existence of short-term association between economic changes and vital rates (Galloway, 1988; Hammel, 1985; Richards, 1984; Lee, 1981), whereas in contemporary industrialized world, findings are obscure, controversial (Lee, 1990), and inconsistent among different nations.

There are several generalizations permitted by sufficient number of studies in pre-industrial societies, as Lee (1990) summarized: both mortality and fertility do respond to economic fluctuations, even for small price variations and food price reduction, and spreads out over a number of years, which are the greatest responsibility for population loss; but such responses to severe economic crisis is seldom a quantitatively important influence on population trends since the population size and age distribution change more slowly than the fluctuations and loss is rather temporary; the mortality increase may be lagged rather than a contemporaneous effect, and followed by a period of below-normal mortality, whereas fertility responds in a regular fluctuating pattern shaped by the biology of the birth interval; Such shared patterns being generalized is mainly due to a common methodology employed by previous studies, using fluctuations in food prices and climate condition as the explanatory variables for the demographic changes, which permit a comparative analysis.

Mortality

Mortality might be increasing during the period while living condition is worsening. In an agrarian society, most of the population was living close to the subsistence level, whether there is harvest which allows sufficient food consumption is highly dependent on the contemporaneous weather and environment. During the harsh time that climate is unfavorable to cultivate, failure of the harvest and food price increase (usually use wheat or grain price as proxies) mostly contribute to a reduction in food consumption. Severe production scarcity would cause famine, and it is more likely to eliminate human immunity due to insufficient nutrition intake and expose to

infectious diseases, and subsequently results in mortality increase. Nonetheless, some pointed out that the strength and magnitude of the association between economic changes and mortality in pre-industrial societies based on historical evidences is less than impressive, although the general pattern reflects the existence, direction and trends of the short-term associations (Palloni and Hill, 1997). In addition, the response to severe crisis such as runs of extreme high prices in England between sixteenth and late nineteenth century is very weaker; a study conducted by Lee (1981) carried out that abnormal economic circumstances contributed almost nothing to the explained mortality variance and the lethal effects during the years of high prices is insignificant.

The differences are, of course, obvious between the past and modern world. First of all, harvest failure could be vastly offset by both domestic and global community which is attributable to the development of the financial market, transportation and communication. Moreover, the modern economy is rather complex, not only composite with agriculture, but also non-agriculture sector. The role of former has been diminished in the advanced economy, the latter, in contrary, has been growing disproportionally. Such evolutionary changes determines that most of the magnitude crises are derived from non-agricultural sector such as the most two recent conjunctures in Sweden, the oil crises in 1970s and the financial crises in 1990s, and the influences are rather globally than a single region or nation as the effects were spread out worldwide during the great depression in 1930s. Furthermore, the rise of the modern economy has also enlarged the proportion of population engaging in the wage labor force and being landless. Hence, most people are wage- or salary- earners who would be more sensitive to the economic changes in association with shrinking purchasing power and growing probability of joblessness.

Secondly, pathological effects derived from economic factors also appear differently than the past. With the improvements in technology, standards of living, sanitation and public health, and medical breakthroughs, people are less likely to suffer from malnutrition and be vulnerable to infectious diseases, thus such causes of mortality turns out an irreversible decline in a present context. Nevertheless, some new epidemics induced by economic change have arisen and attracted considerable attentions by many researchers in varied fields. The role of "stress" during the hardship (e.g. income loss or jobless) is suspected as an important cause of various physical and mental disorders, and sequentially implicate to cardiovascular disease, cerebrovascular disease, heart diseases, and ischemic heart diseases that constitute the major causes of morbidity and mortality in the developed countries. One of the most influential writers, Brenner (1987) found that economic growth plays a principle role in reducing mortality at nearly all ages, whereas economic recession, measured by three economic indicators that short-term declines in real per capita income, increased rates of business failure (bankruptcy rate) and increased unemployment rate associated with three additional behavioral risk indicators that alcohol consumption, cigarette smoking and fat consumption, is positively related to total mortality for virtually all age groups, in both sexes, for major causes of death and causes due to psychopathological conditions[2]. Another study conducted by Brenner in 1983 also

[2] A summary of findings contained in M. Harvey Brenner's report: Importance of Economic Change in Swedish Health and Social Well-Being, 1950-1980, prepared for the Swedish National Health and Welfare Board, Socialstyrelsen, Stockholm. Data analyzed for this paper were obtained from the Swedish National Health and Welfare Board, Socialstyrelsen. The data originated largely with the Central Statistical Bureau, Stockholm.

revealed that one percentage point increase in the US unemployment rate results in extra 36,887 deaths over the course of following 6 years. This finding, therefore, has attracted considerable attention from the government and policy makers. According to this point of view, the connection between economic changes and mortality seems still being tight in the modern society and the only thing differentiated from the past is the pathological causes of deaths, from traditional to new (and more various) epidemics.

Brenner's work and his assertion of strong adverse health consequences of recession, however, have been heavily criticized mainly stem from two perspectives. One is regarding the econometric methodology underlying Brenner's work. A considerable number of studies (Gravelle and Hutchinson, 1981; Gravelle *et al*, 1981; Stern, 1981 and 1983; McAvinchey, 1983 and 1984; Sogard, 1983; and Kasl 1979 and 1982) contributed to some generalized criticisms which are concerning the variable definitions, data reliability and adequacy, selection of variables, time-series fallacy, the strength of the underlying relationship in the model, lag structure and the use of aggregate data. The other side of the critiques is attributable to a fairly recurrent idea of population theory that the frequent and sharp fluctuations in the levels and age patterns of mortality have been weakened and which is an important marker distinguishing mortality trends in pre- and modern societies (Livi-Bacci 1992; Vallin 1991; Flinn 1974; Schofield and Reher 1991). Palloni and Hill (1997) also argued that mortality trend is following an irreversible downturn and the frequency and duration of oscillations around secular trends were reduced to insignificance or, for all purposes, disappeared altogether[3]. Furthermore, plenty of evidences of recent mortality trends are strongly against Brenner's results and agree in an important regard that economic crisis and structural adjustment typically have not led to an increase in mortality. Some studies of mortality trends in Latin American indicate no cases in which mortality has increased (Palloni, 1989; Bravo, 1997). Similar results are also carried out by Hill and Pebley (1988) that Ghana is the only country experienced children mortality increase (under age five) during the 1980s.

According to a considerable number of studies on the relation between economic changes and human well being, the pattern of mortality response is quite common and well-understood for the historical societies, whereas remains controversy for the present. Therefore, several questions are raised here: Is Brenner right about the magnitude adverse effect of economic change on population well-being in a modern context? More literally, are people still vulnerable to economic recession? And would mortality increase to the higher level than it would otherwise have been because of the severe economic crisis? Or the effects has been disappeared or mitigated like some other studies have argued?

Fertility

Fertility does respond to economic changes and its shared pattern has been well-established for traditional societies by large number of historical studies. The historical population data in England, 1548-1834 reveals a strong negative relationship between fertility and wheat prices, and which appears an approximate linear shape, by which is meant that little disproportional fertility decline is found as

[3] Fogel (1989, cited in Palloni and Hill,1997) "Although apparently harmless, the idea that the disappearance of crises-mortality can be taken as a marker of modern mortality ought to be carefully qualified since it is by no means clear that their contribution to the high levels of mortality prevailing during pre-industrial times was inordinately high".

the prices reach the point of extremely high (Lee, 1981). Thus the fertility response to short-term fluctuations has been confirmed in the pre-industrial world, whereas to severe agrarian crisis is less impressive.

The reasons why fertility might be responsive to price change do vary at different stages of the demographic transition. In historical population, the early stages of demographic transition, marital fertility decline during the harvest failure is mainly dominated by the absence of the husband in search of work and famine amenorrhea (Lee, 1981). Some also claimed that the age at marriage and fecundability (menarche) may be responsible for total fertility decline (Mason, 1997). Furthermore, Bongaarts and Menken (1983) identified five determinants of natural fertility rate, and stressed on two of them, age at first exposure to intercourse and variation in postpartum infecundability, are the most important since one determines the starting age of childbearing and the other determines the birth interval. Another worth noting factor is the age at which childbearing ceased, however it is unsure so far as in some population, women can be reproductive up to age 50, yet some only up to 45, and, in addition, the variation in the age of menopause may be attributable to nutrition, yet the substantial influence on completed family size or current fertility will be small given the low rates of childbearing among woman in their forties (Gray, 1983). All of these determinants are regarded as supply side factors because of the absence of induced abortion and contraceptive techniques in the traditional societies. Hence, the supply of children can respond pro-cyclically to economic fluctuations, particularly in the age at marriage. Under severe crisis, physiological factors might play a key role determining the pro-cyclical effects because famine, malnutrition and infectious diseases could be likely to occur, which would, in turn, deteriorate fecundity. There are ample of evidences suggest that severe economic crisis can have a pronounced impact on fertility in the short run even on the secular response of fertility. A study of Dutch famine of 1944-45 (Stein *et al.*, 1975) revealed a strong association between food availability in urban areas and births nine months later. The total fertility drop by 2.7 births during the great leap forward was also well-documented by Ashton *et al.* (1984) and Coale (1984). Hence, in short, if famine is induced by sufficient deterioration of the economic conditions, the impact on fertility would be substantial and physiological, but no lasting.

In contrary, in the secular developed nations, children are more like being a product or part of consumption within household instead of family labor supply. Moreover, couples are more capable to form their family size as desired and time childbearing due to large availability and low cost of contraception. Therefore, along the demographic transition process, fertility fluctuations are dependent on from more supply-side factors to demand-side factors. As children are treated as consumer goods in the standard new home economic model of fertility (Mason, 1997), higher income would lead to higher demand for children (Becker 1960). This hypothesis has been confirmed by many studies of childbearing in well-developed countries. Hence there is a positive relation between fertility and economic fluctuations, an upswing would encourage couple to be more reproductive, whereas a downturn would encourage couple to postpone childbearing. A severe economic downswing also creates substantial uncertainty of long-term income, which would lead couples to revise their potential income in order to smooth the future consumption, thus timing childbearing may be a solution to match consumption needs (number of children are desired) and

income. Such positive association belongs to pro-cyclical response, similar to historical events, but induced by demand – side factors instead of supply – side factors.

Nevertheless, Lee (1990) summarized that many old studies drew the conclusion that fertility was pro-cyclical in developed countries during the first half of the twentieth century, no one, however, has shown that the pro-cyclical pattern has continued to hold since the 1950s. In many developed settings, female labor participation and wage level are rather high relative to less developed third world, e.g. in Sweden, the female-to-male relative wage has a strong trend of improvement from 1913 when the ratio is rarely 58 percent to 1995, it reached 90 percent, which have a magnificent contribution to the negative relation between relative wage and total fertility rate in Sweden 1915-1999 (Stanfors, 2003). Unlike the rural societies, the conflict between work and childbearing is considerable in industrialized economies where work and home are physically separated (Mason, 1997). Therefore, under the good economic circumstances, although couples would be affordable to more kids, the opportunities costs of childbearing would be heavier, particularly for fertile women, than poor economic times so that postponement of childbearing is likely, which may elicit a counter-cyclical response. In addition, fertility variations may be also determined by a wider range of factors as in Sweden which are found that a change in preferences and an increased demand for children of higher quality, the introduction of inexpensive and efficient contraceptives, the effects of the World Wars, social policies, the emergence and growth of the Swedish welfare state, in particular with respect to labour market policy and family and tax policy (Stanfors, 2005).

The pattern of fertility responses have been also varied during the different periods of the twentieth century as in the study on the Swedish population conducted by Stanfors (2005) carried out that the fertility response to female-to-male relative wage changed from a counter-cyclical pattern during 1915-1975 to a pro-cyclical pattern during 1975-1999, whereas response to economic conditions, measured by investment ratio, changed another way around, from pro- to counter-cyclical pattern.

Hence, in summary, there is considerable uncertainty of fertility response to economic changes in the modern economies. Some questions are noteworthy: first of all, is the association between fertility variation and economic fluctuations still significant? Further more, does severe economic depression have strong influence on the birth rate? If so, the response is pro- or counter-cyclical? My guess is that in most advanced economies, once fertility rate has reached the lowest-low level, its recovery is unlikely to occur during the good economic time because of the raising opportunity cost of childbearing which is, for instance, associated with increasing demand for female labor, female wages and/or female human capital investment in Sweden (Stanfors, 2005). On the other hand, although severe depression may lead people loss job and income, but which would be insufficiently to reduce the opportunity cost of bearing child since both young man and woman may seek some other activities to participate such as education or training programme, and, therefore, fertility rate would still remain at low level. In addition, there is likelihood that magnitude crisis may further lower the fertility in a society with widely accepted and low cost contraceptive methods, however how far it can go down is still an open questions. Therefore, in short, it seems that the fertility response to economic changes is insignificant, and

neither pro- or counter-cyclical.

2.2 Theoretical Background

There is a large bibliography of historical studies on the demographic response to economic crisis. An investigation in the short-term variations in vital rates, prices, and weather in pre-industrial England conducted by Lee (1981) is the most pioneering study applying modern statistical and econometric methodology in this field, which examined the demographic responses to not only annual harvest fluctuations, but also severe crisis. Many other researches employed the same method to look at such associations in some other pre-industrial European countries (e.g. Richards, 1983; Galloway, 1985; 1988). The following theoretical review discusses the way to measure the economic changes, vital rates and econometric model developed in previous studies.

2.2.1 The Measurement of Crisis

The types of crisis are varied in different contexts and periods. In agrarian economy, most crises originate in a weather-induced harvest failure, in which agricultural prices increase because of the reduction in output[4], yet sometimes a sharp rise in food price arises from inaccurate expectation of grain speculators (Sen, 1981 and Ravallion, 1987, cited in Lee, 1990). In such scenarios, fluctuation in prices and weather temperature were the basic exogenous factors explaining the vital rates change. The price of grain is the dominant determinant of the real wage, therefore could be taken as an indicator for standard of living within traditional context (Galloway, 1988; Lee, 1981; Weir, 1984; Livi-Bacci, 1991; Appleby, 1979).

The modern crisis, by contrast, may originate from the industrial sector, financial market, or the international economy, such as the global oil crisis in the 1970s and the most severe financial crisis of the 21st century, the US crisis 2007. In contemporaneous developed countries, economies are well-diversified and open, thus price and real wage are unlikely to be a good gauge of individual standards of living, and, at least, they are just one of the components in the economy, therefore their alone would be as an insufficient indicator of the economic performance. In addition, in the modern economy, wages are not only influenced by economic fundamentals, but also political factors, as Dimsdale *et al* (2004) argued that the market wage includes both economic fundamentals (e.g. productivity growth, the replacement ratio, real import prices and unemployment) and the real tariff wage. In their investigation in the Weimar Germany, they found out that real tariff wage was largely determined by income policy variables, thus, in that sense, it is a political wage. So if the difference between market wage and real tariff wage is small, the fluctuations of real wage are substantially influenced by the strength and fortunes of segments of the working class and their political power rather than the economic performance. As a result, during the Great Depression in Germany, unemployment rate climbed from 4.5 percent to 24 percent between 1929 and 1932, real GDP declined at annual rate of 8.3 percent, whereas real wage continued to increase up to 1931 and then dropped down by 2.5 percent annually until the mid of 1930s. As figures shown during the depression, real

[4] Lee (1990), the most typical crisis originates in a weather-induced harvest failure, in which there is simultaneously a reduction in agricultural output and an increase in agricultural prices. This is an unmitigated disaster for landless laborers, may be net beneficiaries, however, for large land-owners, and an intermediate position occupied by small holders. Non-agricultural laborers may be doubly hurt because rural demand for their products may decline at the same time as food price arise.

wage seems rather inertia relative to the other indicators and which even increased somewhat due to the price decline in the early stage of the downturn. Hence, from this point of view, real wage variable is inaccurate to capture the effects of severe crisis and measure the standard of living.

A more comprehensive measurement of the economy, particularly long-term economic growth, is the GDP which includes the gross market consumption, gross investment, gross government spending and gross net between export and import. Unlike real wage or personal disposable income capturing the individual standards of living directly, GDP includes more non-personal elements such as total consumption, and investments, thus it is more weakly related than income variable to the mechanism that trigger the demographic response. Nonetheless, sometimes a reduction of personal disposable income does not necessarily mean lowering the standards of living and, in turn, increasing the mortality, for instance, as elsewhere argues that personal income would be shrinking if the tax financed public expenditure increase, e.g. health care expenditure. Hence, GDP is suggested to be a more satisfactory measure (Gravelle and Hutchinson, 1981; Gravelle *et al*, 1981). In addition, Palloni and Hill (1997) also claimed that GDP include elements intimately related to the maintenance and functioning of infrastructure, sanitation, and public heath. These factors are not measured by income.

Unemployment rate plays one of the key roles in capturing the effects of economic crisis and recession. For example, the first oil crisis in the 1970s bring down the real wage and buying power that leads to a severe depression, which was accompanied by a great deal of structural transformation across a broad range of the industrial core sectors in Western Europe such as coal, iron, steel, shipbuilding, textile and many other consumer goods industries. As a result, cutbacks and restructuring in the traditional base industries led to massive unemployment and the dismantling of entire industrial regions (Magnusson, 2000).

The fluctuations of employment also impose adverse effects on population as a number of literatures regarding the relation between economic fluctuations and population change have strong focuses on the impacts of unemployment on human well-being. One of the most influential writers contributed his finding that unemployment rate is positively related to mortality increase caused by many kinds of diseases at short and relatively lone lags (Brenner, 1987)[5]. Although his model has been widely criticized (Gravelle and Hutchinson, 1981; Gravelle *et al*, 1981; Stern, 1981 and 1983; McAvinchey, 1983 and 1984; Sogard, 1983; and Kasl 1979 and 1982), the critique regarding selecting unemployment rate as an explanatory variable is rarely raised. Nevertheless, some studies concluded that there is little evidence in the aggregate data to support the hypothesis that unemployment has systematically and significantly influence the mortality; it would be, however, a mistake to conclude that unemployment has no effect on heath and mortality (Forbes and McGregor, 1984; Stern, 1983). Stern further pointed out that the hypothesis that higher employment

[5] Brenner (1987) concluded that for total mortality, and mortality due to overall cardiovascular disease, total cerebrovascular disease, and total heart disease, and ischemic heart disease, unemployment rate is positively related. In the short range of lag, for each of these classifications of mortality, the relation usually comes to a peak at a two-year lag. In the long range of lags, the peak is at eight to nine years for total mortality and total cardiovascular mortality, and at four years for cerebrovascular disease mortality.

does not lead to increase mortality or morbidity is hard to test[6] and unemployment seems a likely candidate as a determinant of ill-health, but little reliable evidence supports that it is a *major* determinant of morbidity and/or mortality.

2.2.2 The Measurement of Mortality

There are two different types of rates to measure the mortality, m-type rates and q-type rates. The former is calculated based on a specific calendar time period, namely, period approach, the latter according to the experience of a specific group of people born during a specific calendar period, namely, cohort approach (Hind, 1998). Period approach is the simplest way to calculate and has few constraints on the data, thus is commonly employed in most studies. Nonetheless, it does not reflect the experience of a real group of people, which constitutes the major problem that confronts most previous studies mentioned in the preceding section. For instance, the measure of mortality includes both those who experience unemployment and those who do not, which prohibits the estimation of separate equations for the two groups, therefore make the testing of the hypothesis difficult and vexed (Stern, 1983). The cohort approach does reflect the experience of real group of people, but it has rather high demand on the data set, thus barely available. If such longitudinal datasets are accessible, it would be possible to create a reliable method of testing the hypothesis proposed in most studies on the adverse impacts of unemployment on mortality either on individuals, cohorts or on areas.

2.2.3 The Measurement of Fertility

Similarly to mortality, fertility can also be measured by m-type and q-type rates and there are certain advantages and disadvantages of the two types of rates. For the period approach (m-type rates), it mostly only needs aggregate data that are easily accessible from government statistical agencies, populations census or projections, and some other advantages are up to date and useful for forecasting. Nevertheless, since the period approach only accounts a single year's experience of a given population, thus it would be misleading to estimate the long-run fertility and does not reflect the experience of real fertile women. The cohort approach (q-type rates), on the other hand, is capable to overcome the problems of period approach, however it would impose huge demand on data, therefore expensive and hardly to collect. As the aim of this study is to examine the economic impacts on aggregate fertility fluctuations in the short-run, but estimate the specific cohort fertility and long-term population growth, in addition, the available data set only permit an investigation in period fertility, therefore the discussion here is limited in the m-type rates. The most simplified method to measure the period fertility is calculating the crude birth rate, the total number of births in year t divided by total mid-year population. However a major problem in this ratio is that the denominator includes both people who can and cannot bear children, and therefore enhance the inaccuracy of the estimation. The general fertility rate (GFR) can somewhat overcome the problems arise from crude rates as the denominator only refers to the group at risk of childbearing (the mid-year population of women aged 15-49 years last birthday) instead of the total population. Although there is still some pitfall in the GFR as the probability of a woman bearing children varies at different ages, such problem would be less serious for the purpose

[6] Stern (1983) claims that the problems of testing the hypothesis that higher employment does not lead to increased mortality and morbidity is that the multitude of other socio-economic determinants of mortality and their relation to the incidence of both ill-health and unemployment and a variety of systematic selection.

of this study.

2.2.4 Theoretical Model

Among the studies in the pre-industrial European countries, fluctuations in wheat prices and weather temperature were commonly used as explanatory variables for variations in vital rates (Lee, 1981; Richards, 1983; Galloway, 1985; 1988). According to part of the Malthusian theory, mortality is positively related to wheat price, a positive check, and fertility is negatively associated with wheat price, a preventive check. Such theory has been confirmed by Lee (1981), following a price variation, mortality responded positively, whereas fertility responded negatively. For weather temperature changes, mortality was also positively associated with both cold temperature in winter and hot temperatures in summer; the former is a rather contemporaneous effect relative to the latter that is delayed one or two months. Temperature imposed adverse effects on fertility which was 9 months later in winter and 10 to 11 months delayed in summer.

A common characteristic of most studies in historical settings is using current and lagged prices including lags up to 5 years. Results from one of the most pioneering studies in the pre-industrial Europe, The Population History of England, 1541-1871, revealed that positive mortality responses to price fluctuations were over the first two or three years, and followed by a compensating negative reaction. On the other hand, the pattern of fertility responses was rather predictable; the negative effect may start contemporaneously which suggests that foetal mortality may be key importance, and a fertility recovery may occur followed after one or two years decline because of the biological birth interval. The most profound part of Lee's study is that it not only investigated demographic responses to small fluctuations, but also to severe crisis, as hypothesized that extreme high price would impose additive effects on population. Nonetheless, the results implies that there is no significant additional effect of high prices on mortality, and the pattern of fertility responses to five different price levels (very low, low, high, very high and extreme high) is approximately linear.

In the industrial societies, there is a larger variety of crisis relative to old times and economies are well-diversified and open, thus price and real wage are unlikely to be a good gauge of individual standards of living, as discussed previously. Hence the selection of independent variables and econometric model should be different.

The Mortality Model

One of the most influential models exploring the relation between population mortality rates and aggregate unemployment rates is developed by Brenner in the late 1970s. The model investigating the causal relations between socio-economic change and total mortality are illustrated as Equation 2.1. Brenner anticipated that α_1 and α_4 to be negative and the rest estimates are all positive. The explanations behind this model are: the mortality decline is strongly associated with long-term economic growth because of the improvements in standards of living, technology and medical breakthroughs; however rapid growth, income loss and unemployment increase would impose stress on the population, in turn cause epidemics and diseases, and consequently increase the mortality; for the government expenditure, he assumes that the higher government welfare transfers, the lower the morality rate is. In addition, the model in Brenner's report for the Swedish National Health and Welfare Board,

Socialstyrelsen, Stockholm (Importance of Economic Change in Swedish Health and Social Well-Being, 1950-1980) also includes some behavioral risk factors: alcohol consumption, cigarette consumption and fat consumption. All these factors are of causes of mortality increase.

Equation 2.1:

$$m_t = \alpha_0 + \alpha_1 y^*_t + \alpha_2 (y_t - y^*_t) + \alpha_3 (y_t - y_{t-1}) + \alpha_4 (w_t / g_t) + \sum_{i=0}^{10} \beta_i u(t-i) + \varepsilon_t$$

Where m_t is the total mortality rate, y^*_t is the trend level of real per capita disposable income derived from fitting an exponential trend over the period, $y_t - y^*_t$ is the difference between actual and trend real per capita disposable income, $y_t - y_{t-1}$ is the difference between real per capita disposable income in year t and t-1, w_t / g_t is the share of total government expenditures on welfare transfer payments, the $u(t-i)$ is the unemployment rate and the 10-year-lagged unemployment rates, and ε_t is an error term.

Nonetheless, as discussed previously, the model has been heavily criticized by number of econometricians. The following is some generalized critiques which are relevant to this study:

a) An increase in tax-financed public expenditure (e.g. government transfers to health care programme) would reduce the income and therefore increase the mortality, thus, with this perspective, GDP would be more preferable.
b) It is inappropriate to use government welfare transfers as an explanatory variable which would reduce the mortality rate since some other government non-welfare spending which is also likely to reduce mortality would reduce the share of total government expenditure on welfare transfers, thus some suggested that health care expenditure would be more straight forward.
c) Some important explanatory variables were omitted in Brenner's model such as antibiotic revolution, nutrition improvements, education, and environmental variables, etc.
d) It is impossible to select relevant variables if the estimating equation confounds both production (e.g. linking mortality to behavioral risk factors such as smoking or alcoholism) and demand function (e.g. linking mortality to income, health care expenditure, GDP growth). Hence, some argues that it would be inappropriate to include behavioral factors in an equation based on demand function.
e) It is unrealistic that the lagged unemployment rate would have effect on infant mortality since it is impossible to occur before the child was born or even conceived.
f) Brenner's standard procedure for determining lag lengths and polynomial degrees[7] is arbitrary, thus some argues that the lag structure should appropriately refer to relevant data from independent studies.

In short, even though there are so many disputes surrounding Brenner's model, yet a comprehensive theoretical foundation is still lacking for this kind of study in

[7] The lag lengths is determined by the procedure which starts at a time and increase the lag length until the coefficient on the last lagged variable is insignificant, then exclude the one.

contemporaneous developed world. As Lee (1990) argued that it would be preferable to include wider range of variables, such as environmental, political, and some other non-economic factors, and with a larger collection of studies on a richer set of models, firmer generalization will be possible, nevertheless to include such variables would impose huge demand on data. In addition, whether unemployment would impose significant effects on mortality and whether it is a *major* determinant of mortality increase during economic crisis merit a great consideration. The last, but definitely not the least, is that time-series model would increase the difficulty of testing the hypothesis that higher unemployment, magnitude income loss or GDP decline would lead to mortality increase. Hence, only with longitudinal data would permit the analysis more precisely, however the satisfactory data is rarely available for such studies.

The Fertility Model

There is no universal theoretical model being well-established for the fertility analysis in the modern world, although some early studies followed a basic method, correlation analysis between economic indicators -independent variables- and natality -dependent variable- (Kirk, 1960).

In Kirk's study on the influence of business cycles on birth rate in the US, it covered four periods: the prosperous 1920s; the depression 1930s; the war years and the post war decade, and used three economic indicators: real per capita personal income; the Federal Reserve Board index of industrial production; and nonagricultural employment and unemployment as explanatory variables. The annual deviation from trends generated the conclusion that births respond sensitively to changes in economic conditions, as economic indicators control approximately one-half of the annual variance of fertility from its trend except the unemployment controls relatively low in fertility variance in the postwar period, the association between nuptiality and fertility is insignificant when economic indexes are held constant. Nonetheless, the analysis of relation between major business cycles and fertility trends did not confirm the cyclical effect of economy on fertility since the deviation from trend of fertility moves rather independent of economic fluctuations. However, as reminded that the results neglected the possibility that couple's attitudes and behavior towards childbearing might be influenced during severe prolonged depression and as large widespread methods of family limitation being available; there would be likelihood that fertility at present is more responsive than in the past to major economic downturn.

Further more, even though we know that secular fertility are driven mainly by demand factors in the modern economy as children are more like a consumer product rather than a potential supply in the households, the direction of the momentum is still unclear as, on one hand, an economic upswings should lead to an increasing demand for children, on the other hand, it would, in turn, raise the opportunity cost of childbearing. Hence, the dilemma is that whether the fertility response to economic condition is supposed to be pro- or counter- cyclical, as we discussed in the preceding sector.

2.3 Hypotheses

There are two general hypotheses proposed in this study so as to serve the two research questions specified in the beginning of this paper. As the first research

question proposed that whether the effects of short-term economic fluctuations on the population disappeared, or at least mitigated, in the industrialized world, an appropriate way to get the answer is to explore the difference between now and past. Therefore, I compare the results in present study with the Malthusian framework as the reference in the past with the hypothesis that the magnitudes of demographic consequences of economic fluctuations during the two times are the same if the correlation between variations in economic indicators and vital rates is significant; alternatively they are disappeared if the association is less impressive.

Secondly, to verify whether severe economic crisis would impose magnitude adverse influence on population today, I look at the significance of the association between extreme values of economic indexes and demographic responses, and assume that the impacts of great depression on vital events do exist if the threshold effects are significant, otherwise there is an absence of such additional effects on both mortality and fertility during the severe economic hardship.

Mortality

According to part of the Malthusian theory, mortality is positively related to wheat price, a positive check, by which is meant that the standards of living would decline when the economy goes bad which, in turn, increase the mortality. Hence for the investigation in the short-term fluctuation, I assume that the variation in mortality is strongly associated with economic fluctuations if the positive check still exists, in more detail, mortality would increase when the rate of GDP growth goes down and unemployment rate climb up. About crisis episode, the hypothesis is that there is additional mortality increases when the annual GDP growth is negative or unemployment rate increases to extremely high level if the lethal effects still stand. However, such response is not expected contemporaneously as Lee (1990) argued that mortality increase following an economic crisis may be substantially delayed. Hence, only the effects with one year delayed are valid to this hypothesis, any responses occurred immediately are neglected even if they are statistically significant.

Fertility

Fertility, on the other hand, as part of the Malthusian theory suggests that it is negatively associated with wheat price, a preventive check, meaning that bad economic condition would in turn lower the fertility, whereas good economic condition would increase the birth rate, thus I hypothesize that the annual variation in fertility is significantly related to the variation in GDP and unemployment rate. However the expected direction of the association between fertility and economic change is quite cloudier since, as discussed, the cyclical effects are still controversial based on previous studies, so fertility response could be either pro- or counter-cyclical to GDP decline and unemployment upswings. Therefore, a bilateral hypothesis for this issue is proposed, the fertility goes down when GDP growth slowdown or even below zero and unemployment increase or reach extreme high level if the preventive check is still valid, as a pro-cyclical response, otherwise moves up as a counter-cyclical reaction. Additionally, as Lee (1981) summarized that fertility responses to temperature have certain lag, which are varied in winter and summer, between 9 to 11 months, further more, such delay was also argued by Stanfors (2005) that it takes at least nine month to have a child, from the decision-making proceding conception, thus it is reasonable to make the assumption that the substantial effect of

economic hardship on fertility is with one year of lag.

3 Data

3.1 Source Material

The demographic data for Sweden is collected from the dataset: Population and population changes in Sweden, Year 1749-2007 in Statistics Sweden. I employ a small proportion of the whole dataset covering the period between 1970 and 2007. The raw data contains the age-specific mid-year population, age-specific number of deaths, and total number of births, thus for the deaths rate, the number of deaths is used as nominator and total population as denominator, moreover, in order to avoid the total mortality rate to be distorted by the infant death rate, I further subtracted the number of deaths under age one from the total number of deaths, therefore, the death rate is the non-infant mortality rates, and for the birth rate, the general fertility rate is used as calculated by the ratio of total number of births to mid-year female population aged between 15 and 49. The annual series of mortality and fertility for Japan refers to the Human Mortality Database (HMD) which covering the period between 1947 and 2006, and I use the part from 1971 to 2006. The original Japanese demographic dataset provides the information of the age-specific yearly mid-year population, age-specific number of deaths, and births. Hence I apply the same approach as for Sweden to calculate the non-infant mortality rate and general fertility rate in Japan.

The annual Gross Domestic Product series of the Swedish economy is obtained from the dataset: Gross domestic product (GDP) annual data 1950-, Statistics Sweden. All the values are deflated by the inflation rate and transformed to per capita base on the population in the same year; therefore it is real GDP per capita. The Japanese GDP series is accessed from Economic and Social Research Institute, Cabinet Office, Government of Japan, and the deflation and transformation to per capita follow the same method as for Sweden.

The unemployment data for both Sweden and Japan are all obtained from LABORSTA Labour Statistics Database over the period between 1969 and 2007, which is published by International Labour Organization Geneva.

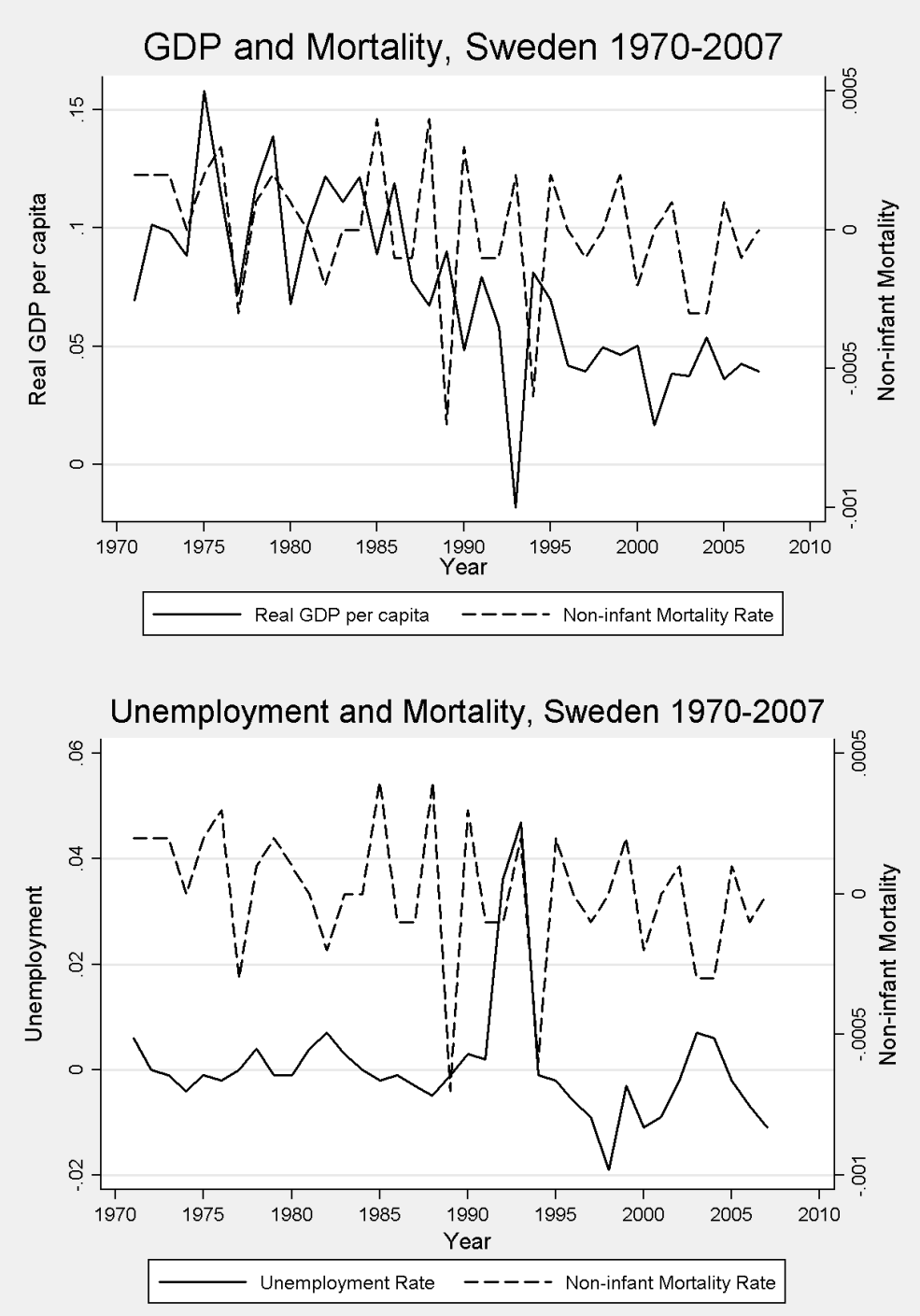
3.2 Description of Data

The annual changes in economic indicators and vital rates in Sweden are illustrated in both Figure 3.1 and 3.2, where the short-term fluctuations of real GDP per capita, unemployment, non-infant mortality and general fertility rates are displayed. They show a severe economic downturn in the early 90s, at which, the unemployment increased by 3.6 percent in 1992 and 4.7 percent in 1993, and GDP revealed a negative growth (-1.8 percentile) in 1993.

The annual variation in non-infant mortality is much less impressive comparing to the economic indicators, as demonstrated in Figure 3.1, mostly it is within the range between -0.5 and 0.5 per thousand, except at the years of 1989 and 1994, non-infant death rate went down by over 0.5 per thousand. Coincidently, the two decreases occurred exactly one year after a real GDP growth slowdown in 1988 and a negative growth in 1993, which give a strong impression that economic recession or even

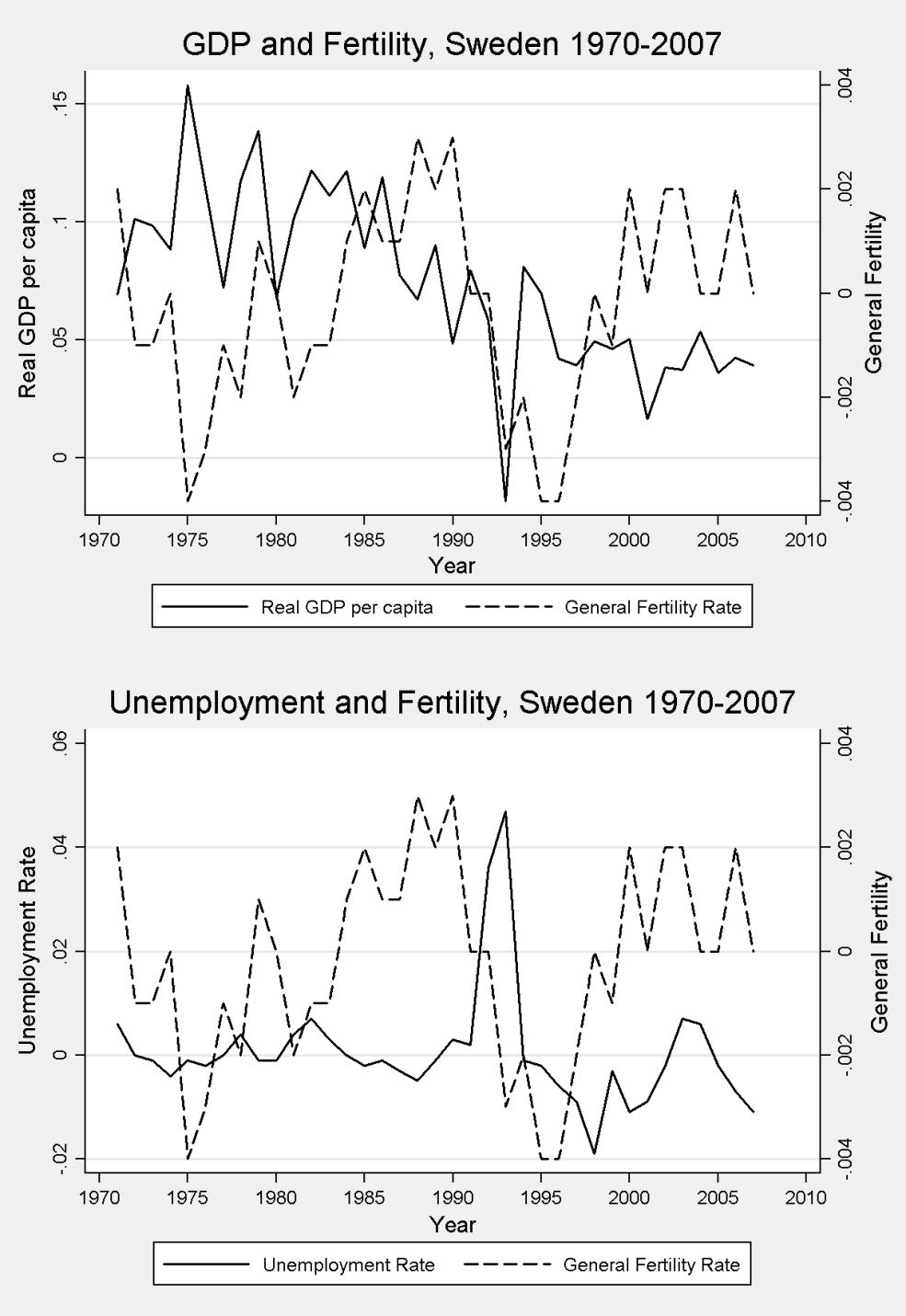
severe depression did not impose any lethal effects on social well-being. On the other hand, a larger variation, in contrary to mortality, is discernable in the general fertility rate as there are visible up and down swings along the dash line in Figure 3.2. Nonetheless, overall, the oscillation of vital rates is rather independent to which of economic indicators, which might imply that the association between short-term fluctuation in Swedish economy and population is less impressive.

Figure 3.1 Economic and Mortality Fluctuations, Sweden 1970-2007



Note: Detrending is achieved by first differencing (and first logged differencing for real GDP per capita)
Source: See Appendix 1

Figure 3.2 Economic and Fertility Fluctuations, Sweden 1970-2007



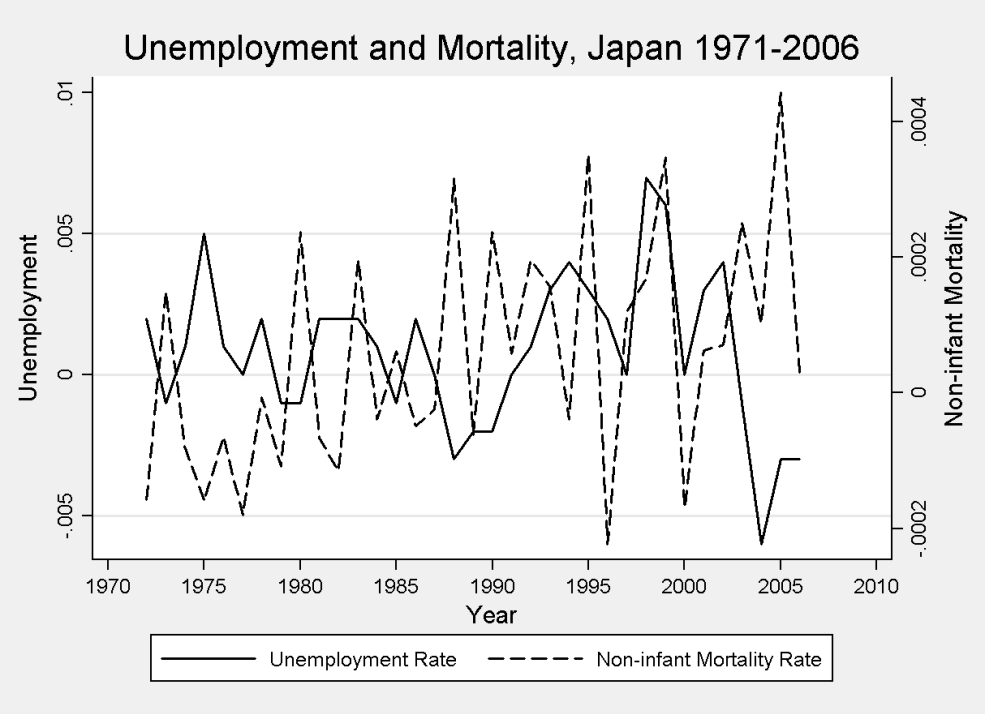
Note: Detrending is achieved by first differencing (and first logged differencing for real GDP per capita)
Source: See Appendix 1

In contrary to Sweden, the figures of Japanese economy behave quite differently, the unemployment rate in particular. The annual change in the rate of jobless is much inertia, as the standard deviation is rather small, stands at 0.27 percent, comparing to 1.14 percent in Sweden. Hence the unemployment rate in Japan throughout the entire period seems as a less impressive indicator of the cyclical changes in economy. Nonetheless, there are still some outliers during the 1990s and early 2000s, as shown in the Figure 3.3 and 3.4; unemployment rates climbed by over 0.27 percent (the level

of standard deviation) at 7 years between 1993 and 2002. Although these numbers are rather insignificant, they still imply somewhat economic downswings which are more vividly discerned by real GDP per capita. Coincidentally at the same year when the upward trend of unemployment commenced, the annual GDP growth was about to slowdown. Since 1993, the real GDP per capita had 4 times negative growth occurred in 1997, 1998, 2001 and 2002, and the rest of the years up to 2007, economic growth was extremely slow, nearly one percent increase annually. Over the whole period, the Japanese economy has experienced three stages, the economic boom was onset during the period between 1971 and 1982, the annual GDP growth stood around 10 percent for most of the years, the most noticeable year is 1975, at which, it peaked at nearly 20 percent. After then, there was a slowdown, the annual GDP growth oscillated around 5 percent till 1992, followed by a dramatic drop in production growth rate (1993-2007).

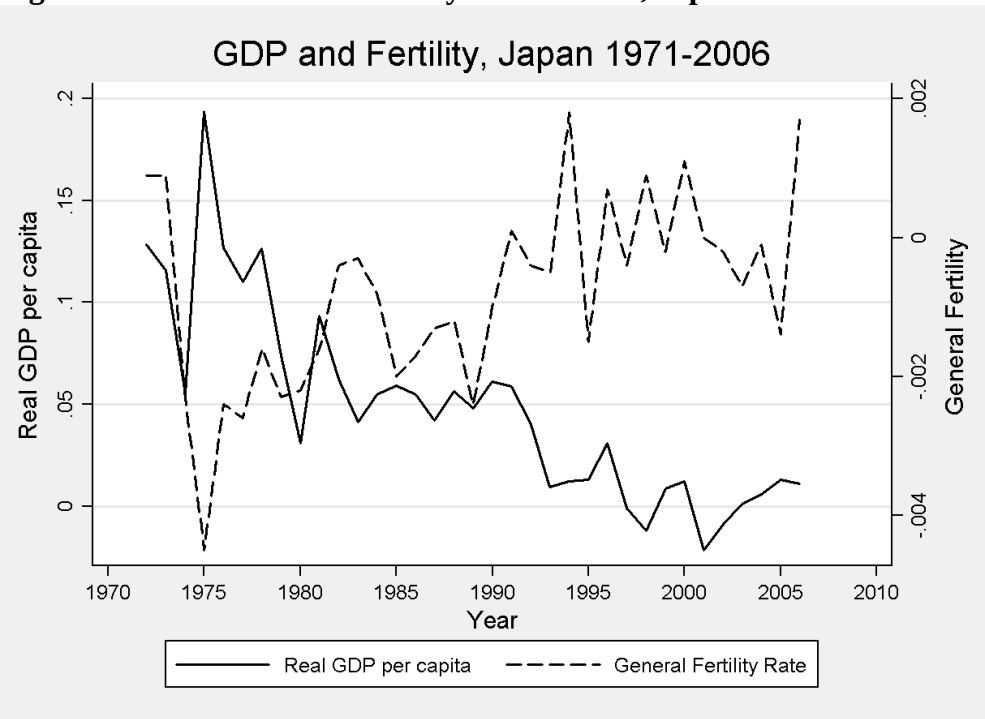
The non-infant mortality series in Japan, illustrated in Figure 3.3, is extremely stationary and independent of GDP growth and unemployment rate. Although, since 1983, the economy was about moving downward and mortality in the most of the years had positive changes, the magnitudes of the deaths increase are extremely small, which peaked at 2005, but with rarely 0.44 per thousand higher than the preceding year. According to Figure 3.4, the dash line undoubtedly implies that Japan is a country with low population growth as the yearly differences in general fertility rate are mostly negative. Nevertheless, there is certain noteworthiness that number of increases in general fertility from year to year are visible since the middle of the 90s, and such positive changes occurred while economic growth was running slowdown or even negative, this might be sort of evidence that the fertility respond counter-cyclically to economic recession or crisis in Japan. However, it can be barely a convincing evidence of the appearance of a fertility recovery because of the small magnitudes of the increase in birth rate.

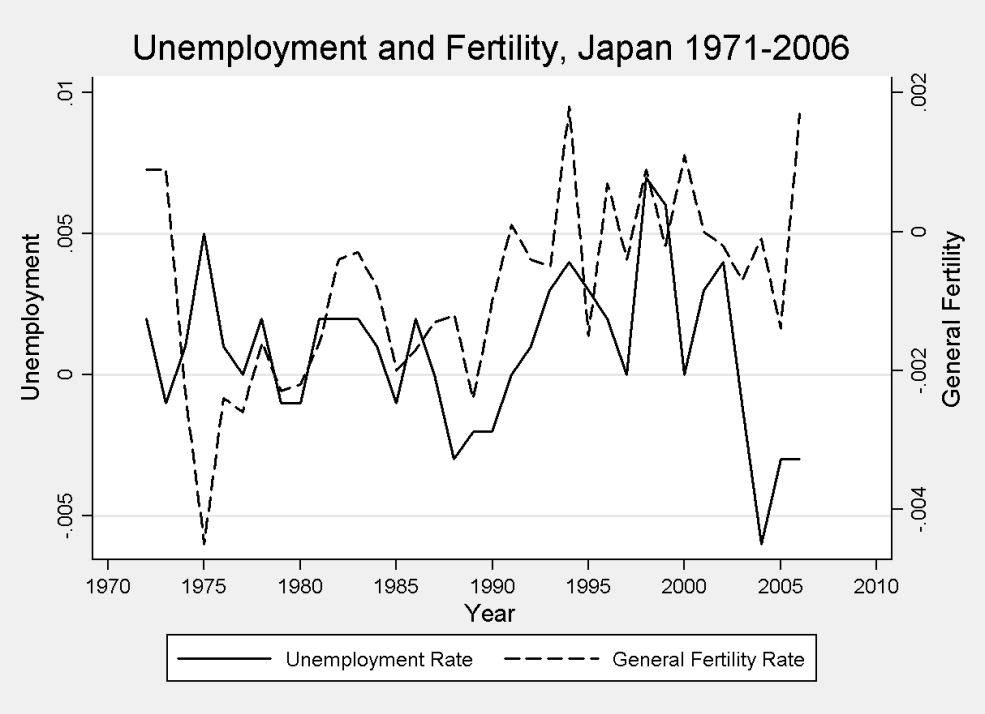
Figure 3.3 Economic and Mortality Fluctuations, Japan 1971-2006



Note: Detrending is achieved by first differencing (and first logged differencing for real GDP per capita)
Source: See Appendix 2

Figure 3.4 Economic and Fertility Fluctuations, Japan 1971-2006





Note: Detrending is achieved by first differencing (and first logged differencing for real GDP per capita)
Source: See Appendix 2

4 Methods

4.1 Detrending and Adjustments of Variables

The most common method for removing the long-term trend and obtaining stationary series is to apply an 11-year moving average (Lee, 1981; Galloway, 1988), which, however, requires a sufficient number of observations. Although over 35-year-long data is enough for applying this detrending methodology, but it would be at the expense of losing the observations at late 20th century which are extremely important for this study. Hence, first differencing is taken as the appropriate way to remove the trend and nonstationarity in the data. Except for the real GDP per capita time series, by which, logged first differences are taken; the other demographic variables and unemployment rate, only first differences are implemented. Therefore, all the variables can be interpreted as annual percentage changes of the series and are capable to capture the effects of short-term fluctuations. To investigate in the impacts of specific crisis, the detrended economic indicators are further broken down into categorical real GDP and binary unemployment variables.

4.2 Empirical Model

The basic statistical model applied is of the type developed by Lee (1981) in the investigation of short-term variations in vital rates, prices, and weather in pre-industrial England that is considered as one of the most pioneering studies adopting modern statistical and econometric methodology in this field, therefore has been widely applied in many other analysis of the association between short-term economic and demographic fluctuations (Galloway, 1985; 1988; Reher, 1989; Bravo, 1992; Richards, 1983). Nonetheless, a major difference is that the explanatory variables included in the empirical model are real GDP per capita and unemployment

rate instead of prices and weather temperature, as argued earlier that in the modern economy, there is a larger variety of crisis relative to old times and economies are well-diversified and open, thus price and real wage are unlikely to be a good gauge of individual standards of living, therefore the selection of independent variables and econometric model should be different.

In addition, the model also shares somewhat commonalities of previous aggregate time-series studies in the industrial societies (Palloni and Hill, 1997; Brenner, 1987), such as using unemployment rate as a proxy of economic circumstance. There are, however, several salient differences. First of all, unlike the income per capita in Brenner's Lancet Model, I use real GDP per capita instead as suggested that Brenner's definition of income as personal disposable income implies that an increase in tax-financed public expenditure (e.g. on health services) would reduce income and hence increase mortality, so GDP is a more satisfactory measure (Gravelle and Hutchinson, 1981; Gravelle *et al*, 1981). Moreover, not only is unemployment rate, but also real GDP per capita is included as explanatory variable that is because the two serial data behaved differently over the whole period, as shown in Figure 3.1-3.4, further more, the implications of the two variables are also different during hardship and normal or prosperous. During the severe economic downturn, such as in the 1930s, massive unemployment was experienced through a large number of population, thus the supposition of employment as the decisive factor is valid, while for the good time, on the other hand, only small segment of the population is directly affected directly by unemployment, therefore the impacts of economic activity or the level of income and prices would be more significant than unemployment *per se* (Kirk, 1960) Hence by using both unemployment rate and real GDP per capita may help capture different effects from each indicator on the population. Finally, the model is developed on the grounds of demand function, therefore such behavioral risk factors, for example, alcohol consumption, cigarette consumption and fat consumption are omitted.

The distributed lag model is key important for the studies concentrated on the demographic responses to economic change as the reactions is not necessarily contemporaneous with the crisis and may be substantially delayed, mortality may be followed by a period of below-normal level and fertility would be shaped by the biology of the birth interval (Lee, 1990). Among the many possible variations of the basic distributed lag model, some studies conducted with up to 10 year lags, which is certainly preferable as the length of data is sufficient. However, the series employed in this study cover only about three decades and a half, and such high order of lags would significantly reduce the number of observations, thus I have specified one of the simplest versions of the distributed lag model with up to one year of lag since, as discussed in my hypothesis, both mortality and fertility responses are substantially apparent with approximately one year delay in accordance with many other previous studies, and including corrections for autoregressive disturbances.

Besides the distributed lag model, the general strategy of the analysis of short-term fluctuations is also similar to the one developed by Lee (1981), by which, it started with an estimation of the linear relationships among fluctuations in the variables that were assumed to hold over the entire period, and later the changes in the relationship by sub-period, the threshold effects, and the effects of runs of bad harvests are examined. Nonetheless, there are several salient differences regarding the approach to

measure the magnitude economic crisis in this study. As the data series is relatively short, thus it is inappropriate to create sub-periods to look at specific crisis or period with extremely unusually prices like Lee (1981) and some others do. Furthermore, as mentioned in Chapter 3 that the annual change in the rate of jobless in Japan is much inertia, as the standard deviation is rather small, stands at 0.27 percent, therefore, for the threshold effects of extreme high rate of unemployment, I introduce the dummy variable instead of multi-categorical variable as was done in Lee's study in 1981 for wheat prices. The definitions of the dummy are discussed in more detail in the section of definition of variables. However sufficient annual variations in the growth rate of real GDP per capita are discernable in the GDP series, hence the procedure of categorizing variable is applied so as to examine the threshold effects and non-linearity. A detail description of categorical variables regarding the growth in real GDP per capita is illustrated in the variable definition.

Equation (4.1) illustrates the general forms of the empirical model, among which, Model A is for the investigation of association between economic fluctuations and variation in vital rates, whereas Model B and C are with the purpose of looking at the threshold effects of severe economic depression on population. The estimation employs ordinary least squares (OLS) with one year of lag on first differenced log real GDP per capita and unemployment rate. As the real GDP per capita and unemployment rate are specified as the annual percentage changes in Model A, hence all the β's can be interpreted as elasticity, whereas in the last two models, the independent variable is transformed into dummy and categorical variables, thus the interpretation could be made as the substantial meaning of the vital rates, number of deaths or births per thousand. The specifications of all the variables are discussed, in a great detail, in the following section: definition of variables. In addition, autoregressive estimator is included in each equation, by doing this is not only so as to avoid the serial-correlation problem, but also with some theoretical reasoning. Both mortality and fertility could be dependent on their one year lag as Lee (1991) summarized that mortality increase may be followed by a period of below-normal mortality and fertility responds in regular fluctuating pattern shaped by the biology of the birth interval. That is to say that a significant mortality decline could occur after a mortality crisis during which most vulnerable group may pass away and the leftovers are relatively stronger, thus at much lower risk to death, same as the fertility, a baby boom could be followed by a baby bust since most female are in the breastfeeding period and not reproductive after the year of childbearing.

Equation 4.1:

Model A

$$y_t = \alpha_0 + \sum_{i=0}^{1} \beta_1 (GDP_t - GDP_{t-1})_{t-i} + \sum_{i=0}^{1} \beta_2 (Unempl_t - Unempl_{t-1})_{t-i} + \beta_3 AR(1) + \varepsilon_t$$

Where y_t denotes the dependent variable (annual variation in vital rates at time t), α_0 is the constant, β_1 represents the elasticity coefficients of annual change in real GDP per capita with distributed lags up to one year, β_2 represents the elasticity coefficients of annual change in unemployment rate with distributed lags up to one year, and β_3 is the first-order autoregressive estimators, and ε_t is the error term.

Model B

$$y_t = \alpha_0 + \sum_{i=0}^{1} \beta_1 GDP\_Level_{t-i} + \beta_2 AR(1) + \varepsilon_t$$

Where y_t denotes the dependent variable (annual variation in vital rates at time t), α_0 is the constant, β_1 represents the coefficients of categorical variable: the level of annual growth in real GDP per capita with distributed lags up to one year, β_2 is the first-order autoregressive estimators, and ε_t is the error term.

Model C

$$y_t = \alpha_0 + \sum_{i=0}^{1} \beta_1 udummy_{t-i} + \beta_2 AR(1) + \varepsilon_t$$

Where y_t denotes the dependent variable (annual variation in vital rates at time t), α_0 is the constant, β_1 represents the coefficients of dummy variable: unemployment increases at extremely high rate with distributed lags up to one year, β_2 is the first-order autoregressive estimators, and ε_t is the error term.

4.3 Definition of Variables

4.3.1 Vital Rates

The nominator of the death rate defined in the statistical model excludes the infant deaths in the same year, thus the final ratio measures non-infant mortality *per se*. Fertility, on the other hand, is calculated by fraction of total number of births to mid-year female population at risk of childbearing (aged between 15 and 49), therefore, namely general fertility rate. Additionally, both mortality and fertility rates are first differenced, that is to say it is the annual variation in the vital rates.

4.3.2 Economic Indicators

The explanatory variables, both real GDP per capita in logarithm and unemployment rate are detrended by first differencing, thus they represent the annual percentage change and can be interpreted as elasticity for the association between short-term fluctuations and variations in vital rates.

Nonetheless, in Model B, I have introduced categorical variable for GDP growth rate in Sweden and Japan, as shown in Table 4.1 and Table 4.2, the levels from extreme low to extreme high are distinguished by standard deviation, 3.7 percent for Sweden and 4.9 percent for Japan, and for extreme low and high levels of GDP growth, I define the former as negative or no growth, and the latter as annual increase over 11.1 percent for Sweden and 14.7 percent for Japan. The Swedish GDP growth rates during 1970-2007 are with a maximum value of 15.8 percent and a minimum value of -1.8 percent. The yearly difference in real GDP per capita in Japan is with a peak at 19.4 percent and its bottom at -2.2 percent.

In Model C, a dummy variable for extreme high rate of unemployment has been generated, however the definition of the dummy unemployment variables are different in the case of Sweden and Japan, in the former country, the dummy variable equals to one represent the annual unemployment rate has increased over 2 percent, but only

0.25 percent in Japan since the standard deviation in the latter is much smaller, as discussed in the preceding section, nevertheless, they are all treated as outliers because abnormal variations are discernable, alternatively, if the dummy equals to zero, by which is meant that the oscillation of annual unemployment rate is within the normal range, thus assume no adverse effects are imposed on demographic change.

Table 4.1: Categorical Annual Growth in Real GDP per capita Variable for Sweden

Category Label	Range	Number
Extreme Low	< 0	1
Low	0 to 0.037	2
High	0.037 to 0.074	17
Very High	0.074 to 0.111	10
Extreme High	> 0.111	7

Table 4.2: Categorical Annual Growth in Real GDP per capita Variable for Japan

Category Label	Range	Number
Extreme Low	< 0	4
Low	0 to 0.049	15
High	0.049 to 0.098	10
Very High	0.098 to 0.147	5
Extreme High	> 0.147	1

5 Empirical analysis

In this chapter, all the statistical results are illustrated and followed by a synthetic discussion. The first part of the regression results provides a general picture of the demographic responses to short-term economic fluctuations in Sweden and Japan; later the threshold effects of different levels of real GDP growth per capita and extreme high rate of unemployment are discernable, hereby, certain non-linear relation of both mortality and fertility to annual GDP growth from extreme low to high can be captured. Overall, most of the results have rejected proposed hypothesis, thus against part of the Malthusian theory and some findings in previous studies which have confirmed the positive check for mortality, and preventive check for fertility. Furthermore, there is also somewhat inconsistency being generated across the two developed countries. Another important note is that, in my model, most of the first-order autoregressive estimators are statistically significant and constitutes a much larger size of the coefficients than the rest independent variables; hence one can conclude that the variations in vital rates are rather dependent on it in one year ahead than the economic indicators.

5.1 Statistical Results

5.1.1 Economic Fluctuations and Vital Rates

Table 5.1 illustrates the association between economic fluctuations and demographic changes in Sweden during the period 1970-2007, in which, there is a significant effect of the annual percentage change in GDP per capita on variation in adjusted crude death rate with one year of lag, whereas the sign of the coefficient estimate is on the opposite of what as expected. That is to say that economic fluctuation would induce variation in non-infant mortality a year later, however unlike the expectation that death rate would be driven upward when the economic condition is worsening, in the Swedish case, a 0.3 deaths decline within a thousand population is associated with a 10 percent drop in real GDP per capita. This estimation merits a consideration not only to the question that whether there is significant impact of economic growth on well-being, but also to that whether the impact is still lethal in the modern economy.

The relation between fluctuations in real GDP per capita and general fertility is almost none as shown that the estimate with either no lag or one year lag is insignificant at 5% confidence level. The fluctuations in unemployment rate does not seem to have any effects on both adjusted mortality and general fertility rates as illustrated in Table 5.1 that none of the coefficient estimates and their lags are even close to the five percent significant level.

The results for Japan, as illustrated in Table 5.2, reveal a very different pattern of demographic response to economic changes. Both mortality and fertility are inversely related to fluctuations in real GDP per capita, by which, the former demonstrates a 0.15 per thousand declining with one year delay and the latter reveals a 1.55 per thousand decreasing contemporaneously while there is a 10 percent increase in real GDP per capita. The mechanism of mortality is indeed in line with both part of the Malthusian theory and my hypothesis that death rate climb when economy appears a downward trend. The pattern of fertility is against part of the Malthusian theory and implies a counter-cyclical response to real GDP fluctuations. Nevertheless, the fertility decline is only significant at zero lag with a considerable size of the coefficients, by which is meant that an immediate response could occur within one year. A possible explanation for such quick response is that the significant fertility loss might implicate to foetal loss or induced abortions, which is, however, just a speculation since such convincing evidence can only be attained by using a monthly data series like what had been done by Lee (1981)[8]. Similarly to Sweden, there is very little association between the variations in unemployment rate and vital rates as illustrated that not only adjusted crude death rate, but also general fertility rate at both lags is even far from 10% significance level.

Table 5.1: Vital Rates and Short-term Economic Fluctuations, Sweden 1970-2007; OLS Regression Coefficients, t-statistics and p-values

	△*ACDR*			△*GFR*		
Independent variables	coef.	t	P>t	coef.	t	P>t
△GDP						
lag 0	-0.0006	-0.4700	0.6400	-0.0095	-1.0200	0.3160
lag 1	0.0030	2.4300	0.0210	0.0075	0.7600	0.4530
△Unemployment						
lag 0	-0.0001	-0.0100	0.9890	-0.0499	-1.5800	0.1240
lag 1	-0.0030	-0.7700	0.4480	0.0024	0.0800	0.9400
AR(1)	-0.3768	-2.4900	0.0180	0.5738	3.8200	0.0010
Constant	-0.0002	-1.9600	0.0590	0.0000	0.0100	0.9900
R2	0.3628			0.3893		
BG test (Prob>Chi2)	0.1763			0.6678		
Number of observations	36			36		

△ACDR = first differenced Adjusted Crude Deaths Rate (infant deaths excluded).
△GFR = first differenced General Fertility Rate (Births divided by female population aged 15-49).
△GDP = Annual percentage change in real GDP per capita.
△Unemployment = Annual percentage change in unemployment rate.
AR(1) = first-order auto-regressive estimator.

[8] A study on historical population in England 1541-1871 concluded that there is a strong negative association between prices and marital fertility fluctuations, beginning after a lag of about 3 months, and peaking at 9 or 10 months. This suggests that foetal loss may have played an important role (Lee, 1981).

Table 5.2: Vital Rates and Short-term Economic Fluctuations, Japan 1971-2006; OLS Regression Coefficients, t-statistics and p-values

	△*ACDR*			△*GFR*		
Independent variables	coef.	t	P>t	coef.	t	P>t
△GDP						
lag 0	-0.0011	-1.4900	0.1470	-0.0155	-2.3100	0.0290
lag 1	-0.0015	-1.8500	0.0750	-0.0020	-0.3400	0.7400
△Unemployment						
lag 0	-0.0101	-0.9800	0.3360	-0.0155	-0.1800	0.8550
lag 1	-0.0100	-0.9700	0.3400	0.0778	0.9200	0.3640
AR(1)	-0.5263	-3.2600	0.0030	0.0398	0.2100	0.8380
Constant	0.0002	5.2600	0.0000	-0.0001	-0.1700	0.8680
R2	0.4316			0.4074		
BG test (Prob>Chi2)	0.5380			0.0195		
Number of observations	34			34		

△ACDR = first differenced Adjusted Crude Deaths Rate (infant deaths excluded).
△GFR = first differenced General Fertility Rate (Births divided by female population aged 15-49).
△GDP = Annual percentage change in real GDP per capita.
△Unemployment = Annual percentage change in unemployment rate.
AR(1) = first-order auto-regressive estimator.

5.1.2 Economic Crisis and Vital Rates

Regressions have been run for fertility and mortality on the categorical GDP variables and dummy unemployment variables using the data series 1970-2007 for Sweden and 1971-2006 for Japan, and allowing for effects with lags of zero to one year. I first interpret the results for Sweden. Table 5.3 and 5.4 present the basic regression results of mortality and fertility on categorical growth in real GDP per capita variables. There are five levels of GDP growth rate, from "extreme low" to "extreme high", the "Extreme high" category is excluded in the original regression Model B.

In Sweden, there is a tight association between severe crisis and adjusted mortality occurring at one year lag as illustrated in the first row of Table 5.3 that the mortality response to extreme low growth rate of real GDP per capita is statistically significant at 5 percent confidence level with one year of lag, whereas the effects of such hardship is not lethal at all since a negative sign of the coefficient implies that during the years that real GDP per capita growth was below zero, the non-infant mortality appeared a decline with 0.6 per thousand. Furthermore, except the regression estimate on extreme low level of GDP growth, the rest are all far from statistic significance, therefore one can confirm that the positive association between annual percentage change in GDP per capita and variation in adjusted crude death rate with one year of lag as shown in Table 5.1 is attributable to the significant mortality response to the extreme low rate of real GDP growth.

Figure 5.1 plotted the effects of real GDP per capita categories, from "extreme low" to "very high", on non-infant mortality with zero and one year of lag, and their sum. The most interesting note is the dash line which is also the main interest of this study as discussed that the substantial mortality response is suspected with one year delayed, as it is shown that there is a significant mortality decline when GDP level is extreme low, whereas the rest variations in deaths rate are nearly to zero from "low" to "very high" rate of real GDP growth. According to these threshold effects, besides one can

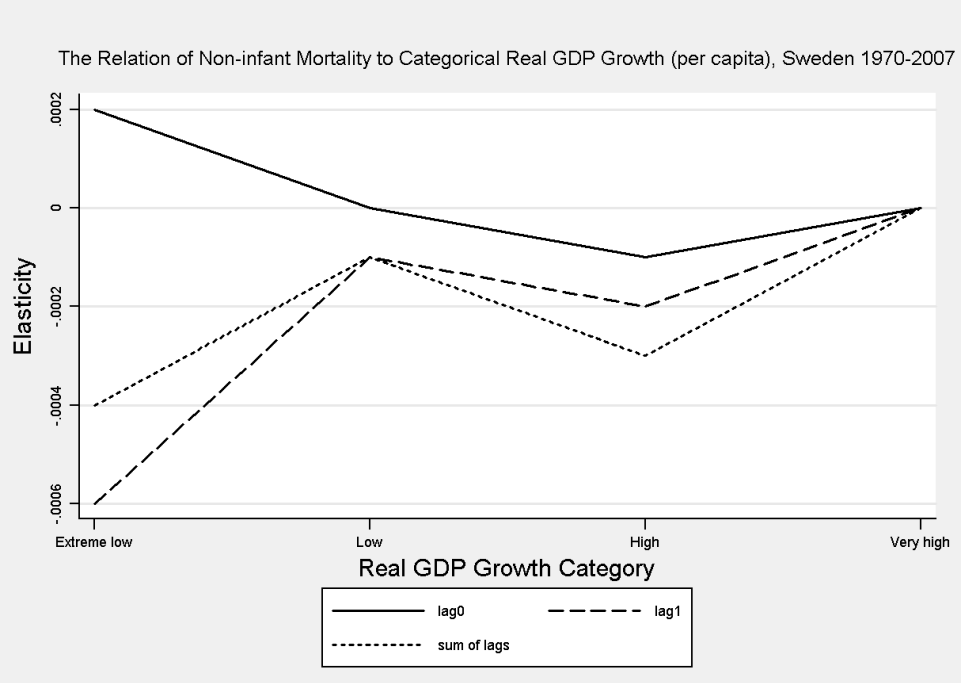
confirmed that the major mortality decline occurred during severe economic hardship is mainly responsible for the positive relation between short-term fluctuations in real GDP per capita and variation in death rates in Sweden. Additionally it can also conclude that the mortality decline is likely to occur during severe economic crisis, but its reverse is unlikely to happen under favorable economic circumstances.

Table 5.3: The Effects of Categorical Annual Growth in Real GDP per capita Variable on Non-infant Mortality, Sweden 1970-2007

	lag 0		lag 1	
GDP Categories	coef.	P>t	coef.	P>t
Extreme Low	0.0002	0.4440	-0.0006	0.0120
Low	0.0000	0.9770	-0.0001	0.7540
High	-0.0001	0.5840	-0.0002	0.1320
Very High	0.0000	0.8290	0.0000	0.7120
	coef.	P>t		
AR (1)	-0.3360	0.0650		
Cons.	0.0001	0.2290		
R2	0.3993			
BG test (Prob>Chi2)	0.2891			
Obs.	36			

Note: The "extreme high" category as the reference is excluded in the original regression. Up to one year of lag for each category, the first-order autoregressive estimator and a constant are estimated by the regression. The autocorrelation of the model is tested through the Breusch-Godfrey LM Test procedure with five lags.

Figure 5.1



The overall threshold effects of real GDP growth on general fertility in Sweden are

rather insignificant. Nonetheless, there is still somewhat counter-cyclical response of fertility discernable with one year of lag in accordance with Table 5.4. Although the impacts of extreme low rate of GDP growth with one year lagged is almost none, as shown that birth rates rarely constitute to a decline with 0.4 per thousand, that of low and high growth rate is noticeable and counter-cyclical as general fertility rate increases by one per thousand when economic growth appears slowdown and drops by 1.3 per thousand as economy is at relatively high level of growth.

Figure 5.2 shows the coefficients with zero and one year of lag in Table 5.4 and their sum of lags. Obviously, none of curves can accept the assumption that there is linear relation between fluctuations in real GDP per capita and birth rate. It is noticeable that the dash curve revealed a fertility gain (one per thousand) with a year delayed when the rate of real GDP increase is low. Moreover, from low to high rate of real GDP growth, fertility dropped by 2.3 per thousand. Hence, one can be evidently argued that the additional effects of categorical real GDP variables are detectable when it comes to low and high rate of real GDP growth. Additionally the promising evidence further implies that the fertility response in Sweden during the period 1970-2007 is counter-cyclical. Nonetheless, in the severe crisis as measure by extreme low rate of real GDP growth, fertility response turns out pro-cyclical, but the magnitude is less impressive.

Table 5.4: The Effects of Categorical Annual Growth in Real GDP per capita Variable on General Fertility, Sweden 1970-2007

	lag 0		lag 1	
GDP Categories	coef.	P>t	coef.	P>t
Extreme Low	-0.0020	0.2790	-0.0004	0.8260
Low	0.0004	0.7650	0.0010	0.4850
High	0.0008	0.3240	-0.0013	0.1160
Very High	0.0000	0.9880	-0.0006	0.4390
	coef.	P>t		
AR (1)	0.6131	0.0010		
Cons.	0.0003	0.7720		
R2	0.5054			
BG test (Prob>Chi2)	0.8266			
Obs.	36			

Note: The "extreme high" category as the reference is excluded in the original regression. Up to one year of lag for each category, the first-order autoregressive estimator and a constant are estimated by the regression. The autocorrelation of the model is tested through the Breusch-Godfrey LM Test procedure.

Figure 5.2

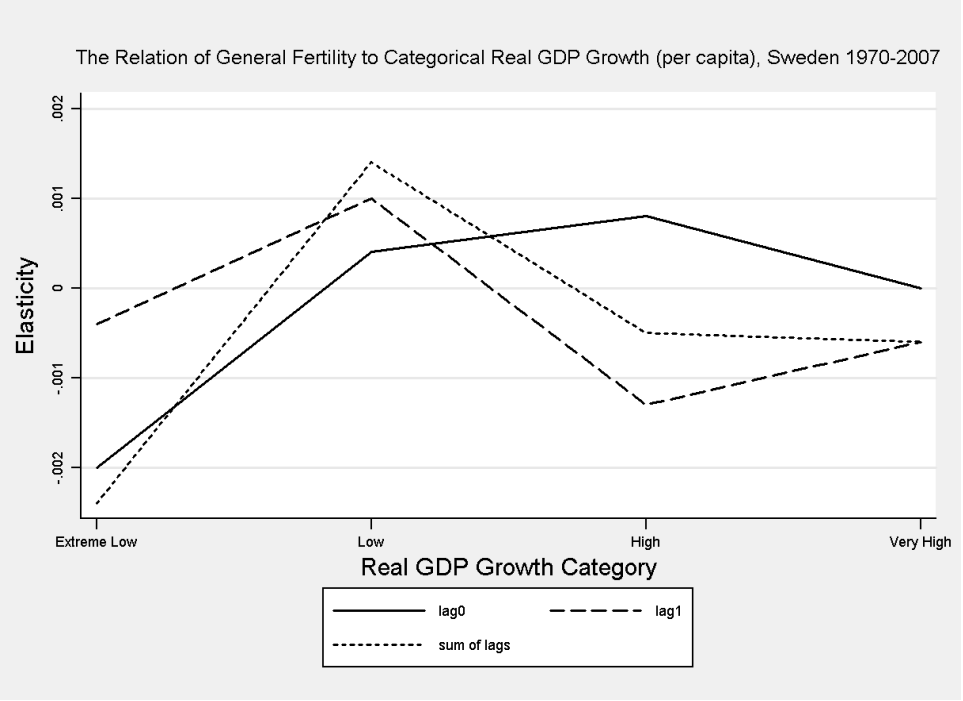


Table 5.5 shows a very weak relation between high rate of unemployment rate and vital rates as none of the coefficient estimates are statistically significant. Hence, not only fluctuations, but also extreme high rate of jobless seems not having any significant impacts on both mortality and fertility in Sweden.

Table 5.5: The Effects of Extreme High Unemployment on Non-infant Mortality and General Fertility, Sweden 1970-2007

	△ACDR			*△GFR*		
Independent variables	coef.	t	P>t	coef.	t	P>t
Dummy variable: unemployment						
lag 0	0.0001	0.7100	0.4840	-0.0008	-0.6100	0.5480
lag 1	-0.0003	-1.3600	0.1830	-0.0013	-0.9200	0.3650
AR(1)	-0.3532	-2.2200	0.0340	0.5206	3.6500	0.0010
Constant	0.0000	0.2200	0.8260	0.0000	-0.1600	0.8710
R2	0.1921			0.3508		
BG test (Prob>Chi2)	0.2375			0.7790		
Number of observations	36			36		

△ACDR = first differenced Adjusted Crude Deaths Rate (infant deaths excluded).

△GFR = first differenced General Fertility Rate (Births divided by female population aged 15-49).

Dummy variable: Unemployment = annual unemployment rate increase (> 0.02).

AR(1) = first-order auto-regressive estimator.

Now consider Table 5.6, which illustrates the threshold effects of real GDP growth on mortality in Japan 1970-2006. Obviously, the “extreme low” variable does impose

significant effect with one year lag on death rate as shown that the coefficient estimate is statistically significant at five percent level. Furthermore, significant response is also detectable with zero lag when it comes to low and high categories, however such response is so quick and needs to be especially cautious to interpret that deaths rates would go up within the same year when economy appears slowdown or relative high growth. A possible explanation of such quick effect might be that the number of deaths caused by suicides or accidents increase, unfortunately such information regarding the causes of death is, however, lacking in the data sets employed in this study. Hence the focus is still landed on the mortality change with one year of lag. Although the one year lagged response seems significant to severe economic downturn, the mortality increase is just 0.4 per thousand which is considerably small. And if take the first-order autoregressive estimator into account, one can conclude that the death rate is rather dependent on its previous year relative to the "extreme low" category.

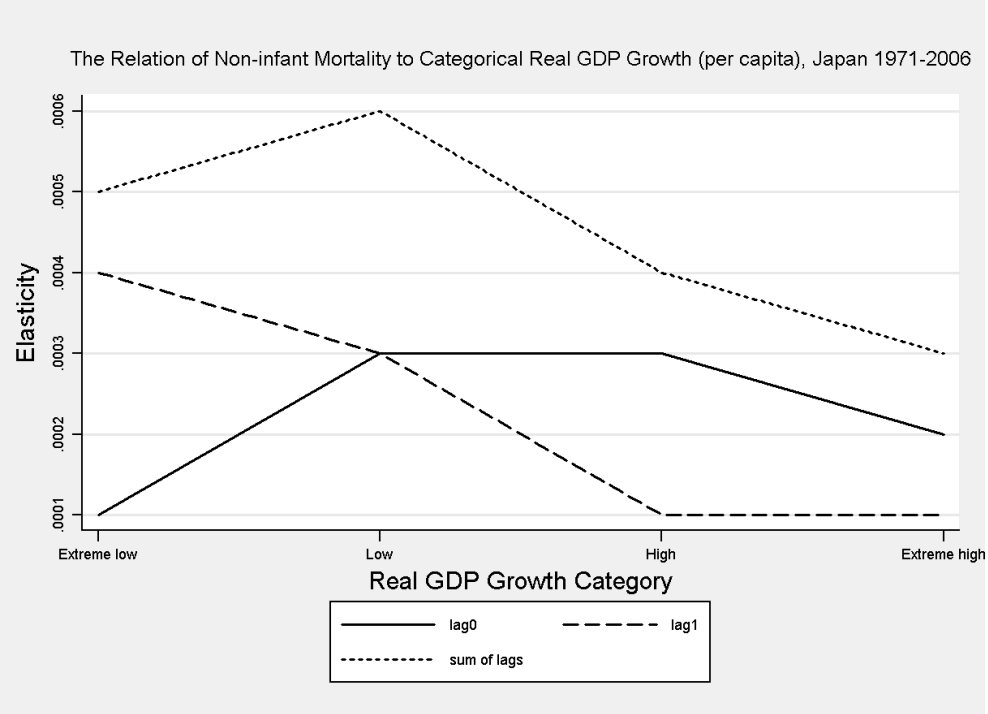
Looking at all levels of economic growth, from negative (lower than zero) to very high (from 9.8 to 14.7 percent); additional effects with one year of lag are discernable at the phase of economic crisis and slowdown as plotted by dash line in Figure 5.3, which is, however, very small, only counts for 0.2 to 0.3 per thousand higher than the good times. Therefore, on one hand, the negative slope presented in Figure 5.3 provides the evidence that mortality is negatively associated with economic conditions, the higher economic growth, the better social well-being, and consequently lower rate of death, on the other hand, it clearly suggests that there is additional lethal effects in the episodes of severe crisis and even low economic growth with one year of lag, but it is too little regarding the number of deaths per thousand.

Table 5.6: The Effects of Categorical Annual Growth in Real GDP per capita Variable on Non-infant Mortality, Japan 1971-2006

	lag 0		lag 1	
GDP Categories	coef.	P>t	coef.	P>t
Extreme Low	0.0001	0.6580	0.0004	0.0380
Low	0.0003	0.0320	0.0003	0.1590
High	0.0003	0.0950	0.0001	0.4360
Very High	0.0002	0.3270	0.0001	0.6550
	coef.	P>t		
AR (1)	-0.7046	0.0010		
Cons.	-0.0004	0.1250		
R2	0.5573			
BG test (Prob>Chi2)	0.4278			
Obs.	34			

Note: The "extreme high" category as the reference is excluded in the original regression. Up to one year of lag for each category, the first-order autoregressive estimator and a constant are estimated by the regression. The autocorrelation of the model is tested through the Breusch-Godfrey LM Test procedure with five lags.

Figure 5.3



The fertility response to categorized growth rate in real GDP per capita in Japan with a year of lag is much less impressive as illustrated in the last two columns of Table 5.7 that the coefficient estimates are far off the statistical significance. However, significant relations toward all GDP categories are discernable at zero lag as shown in the first two columns. Hence, apparently fertility rates do respond to all levels of real GDP growth and with considerable increase. Nevertheless, such immediate fertility response merits great caution of interpretation as argued that it takes at least nine month to have a child, from the decision-making proceeding conception. And the only possibility of real GDP growth rate can explain the fertility increase is that fertile couples feel the economic conditions which are favor in the childbearing and eventually make the decision of that at least within first three months of the year in order that fertile woman may have sufficient time to conceive and deliver the child in the same year. However, such possibility can be only measured by the monthly variance of birth rates, but by annual general fertility rates. Therefore, it would be arbitrary to draw any conclusion on the basis of the results at zero lag.

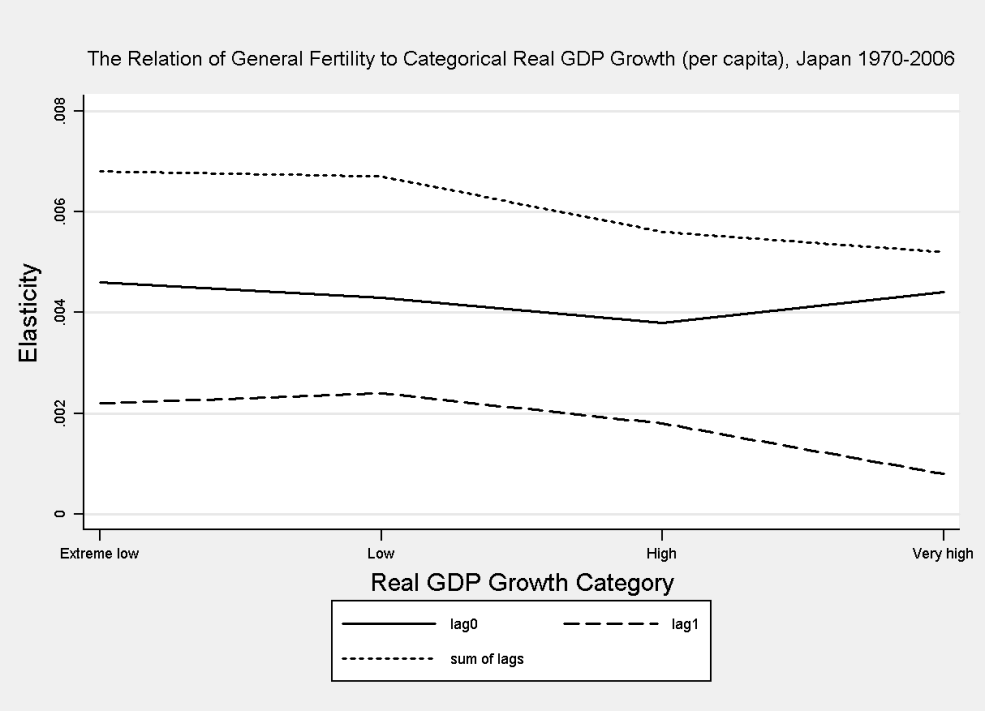
The dash line revealed in Figure 5.4 behaves somewhat non-linearly, and, from "low" to "very high" levels, it indicates that the association between real GDP growth and fertility is negative with one year of lag. Hence, one can confirm the counter-cyclical response. Furthermore, the additional effects during the bad economic conditions as distinguished by "extreme low" and "low" rate of real GDP growth are considerable which constitutes approximately 1.5 per thousand higher in birth rate relative to "very high" category.

Table 5.7: The Effects of Categorical Annual Growth in Real GDP per capita Variable on General Fertility, Japan 1971-2006

	lag 0		lag 1	
GDP Categories	coef.	P>t	coef.	P>t
Extreme Low	0.0046	0.0040	0.0022	0.1920
Low	0.0043	0.0020	0.0024	0.1340
High	0.0038	0.0060	0.0018	0.2780
Very High	0.0044	0.0260	0.0008	0.5410
	coef.	P>t		
AR (1)	-0.1190	0.5920		
AR (2)	0.2609	0.2170		
Cons.	-0.0068	0.0030		
R2	0.6103			
BG test (Prob>Chi2)	0.3059			
Obs.	33			

Note: The "extreme high" category as the reference is excluded in the original regression. Up to one year of lag for each category, the first- and second- order autoregressive estimator and a constant are estimated by the regression. The autocorrelation of the model is tested through the Breusch-Godfrey LM Test procedure with five lags.

Figure 5.4



The association between extreme high unemployment rate and demographic change in Japan is as weak as in Sweden, as presented in Table 5.8, too little significant results to support such association. Therefore, similar conclusion can be drawn for Japan as Sweden that not only do fluctuations, but also extreme high rate of unemployment has

very little significant impacts on demographic changes.

Table 5.8: The Effects of Extreme High Unemployment on Non-infant Mortality and General Fertility, Japan 1971-2006

	△ACDR			*△GFR*		
Independent variables	coef.	t	P>t	coef.	t	P>t
Dummy variable: unemployment						
lag 0	0.0001	1.0100	0.3200	-0.0004	-0.6400	0.5270
lag 1	0.0000	-0.1100	0.9120	0.0008	1.5000	0.1440
AR(1)	-0.1833	-1.0400	0.3060	0.4362	2.4500	0.0200
Constant	0.0001	1.6000	0.1210	-0.0006	-1.7200	0.0950
R2	0.0723			0.2320		
BG test (Prob>Chi2)	0.7357			0.7422		
Number of observations	34			34		

△ACDR = first differenced Adjusted Crude Deaths Rate (infant deaths excluded).

△GFR = first differenced General Fertility Rate (Births divided by female population aged 15-49).

Dummy variable: Unemployment = annual unemployment rate increase (> 0.02).

AR(1) = first-order auto-regressive estimator.

5.2 Discussion

Overall, in accordance with the empirical results discerned in the preceding section, the Malthusian framework is unlikely to be applicable to the contemporary population in both Sweden and Japan since the associations between economic changes and vital rates have been rather less impressive relative to the past and the magnitudes of the demographic responses have considerably weakened, furthermore some counter-cyclical demographic responses are revealed in both countries which, in turn, reject the hypothesis proposed in this research. Therefore, all of these findings merit a magnificent reconsideration of the previous theories within the field of demographic responses to economic changes.

5.2.1 Mortality

A few evidences indicate that the association between economic fluctuations and variations in death rate does still exist in both Sweden and Japan during the last decades, thus which has not completely disappeared. Moreover, there is certain inconsistency across the two countries as the pattern of the mortality response is considerably different, the relation between mortality and real GDP per capita is positive for Sweden, yet negative for Japan. However, one can confirm that the magnitudes of the economic impacts on human well-being have been largely mitigated as in Japan that one percent drop in real GDP per capita would rarely induce 0.015 per thousand increase in non-infant mortality with one year of lag (the elasticity is -0.0015), which is almost nothing comparing to the estimates attained by Lee (1981) that, among the historical population in England 1541-1871, nearly one per thousand mortality increase was driven by only one percent price increase a year ago[9]. Looking

[9] See Lee, R.D. 1981. Table 9.7, "Short-term variation: vital rates, prices, and weather", chapter 9 in Wrigley, E.A. and Schofield, R.S. (1981) The Population History of England 1541-1987.

at the elasticity (0.0015), it is far from falling in the interval between 0.05 and 0.6 that is the range of cumulative elasticity for the positive relation between mortality and prices based on a large number of previous studies on historical population (Lee, 1990). Furthermore, mortality decline is not necessarily associated with economic upswings, it could also occur during the economic downturn as evidence revealed that there is a clear counter-cyclical response in Sweden, the mortality would decrease by 0.03 per thousand if real GDP per capita decrease by one percent.

With the crisis episodes, mortality response to negative growth in real GDP per capita is substantial with one year delay in both countries, but reveal quite different patterns as mortality decline by 0.6 per thousand in Sweden, whereas increase by 0.4 per thousand in Japan. Although the pattern of non-infant mortality response in Japan is quite in line with Lee's summary[10], it is obvious that the magnitudes of such response have been greatly muted as there is just two-fifths person died among thousand people in the episode of economic growth dropped down to below zero in Japan. Moreover, another interesting note is that the impacts of economic crisis are not necessarily lethal to population as the Swedish case indicates a significant decline in non-infant death rate, however such effects are insignificant during the economic upswings as mortality variations are nearly to zero with the rest economic episodes, from "low" to "extreme high" rate of growth.

Regression results also generate some commonality between Sweden and Japan that is that the extreme increase in unemployment rate does not show any significant impacts on social well-being at all, as none of the coefficients, except the auto-regressive estimators and constants, is close to even 10 percent statistical significance as shown in Table 5.5 and 5.8. Such evidences indeed modifies Brenner's strong assertion in the report: Importance of Economic Change in Swedish Health and Social Well-Being, 1950-1980, that economic recession, especially increased unemployment rate, is positively related to total mortality for virtually all age groups. Additionally, some cautions have to be taken into account that most studies conducted by Brenner are covering interwar and war period (post- World War II for Sweden, started with 1950), and the unemployment series does refer to the insured working population as argued by Gravelle and Hutchinson (1981), it would not be surprising that the fall in unemployment rate is exaggerated during the interwar and post-war associated with the mortality decline, and the effects of unemployment increase on mortality are overstated during the war period. Hence, back to the statistical results given in this study, it would be reasonable to hold a belief that the adverse effects of sudden unemployment increase on population well-being have been rather mitigated, or almost disappeared since 1970 than which during the period (interwar, war, and postwar period) that Brenner investigated in, and the largely muted mortality consequence of considerable variation in unemployment rate is not unpredictable in the late twentieth and early twenty-first century.

Given statistics further generate agreement upon some other studies such as Palloni and Hill (1997) argued that mortality trend is following an irreversible downturn and the frequency and duration of oscillations around secular trends were reduced to insignificance, this view has been clearly confirmed by significantly muted variations

[10] Lee (1990) summarized that the mortality increase following an economic crisis is not necessarily contemporaneous and may be substantially delayed. It may be followed by a period of below-normal mortality.

in non-infant mortality presented in Figure 3.1 and 3.3, in which, the annual difference mostly falls in the range between -0.5 and 0.5 per thousand for Sweden and -0.2 and 0.4 per thousand for Japan. Furthermore, the evidences, such as a counter-cyclical response occurred in Sweden and a perfect linear relation between death rate and categorical GDP variables, are also in line with one important regard that economic crisis and structural adjustment typically have not led to an increase in mortality (Hill and Pebley, 1988), therefore, at least, one can conclude that there is no additional lethal effects associated with severe crisis in the contemporaneous population. Finally, the Malthusian framework does not seem to be applicable to the secular population in both Sweden and Japan as either the effects of economic downswings, and even crisis episodes, are not lethal or the magnitudes of mortality response are much less impressive in contrast to the historical population, thus it has confirmed a recurrent idea of population theory by Livi-Bacci (1992); Vallin (1991); Flinn (1974); Schofield and Reher (1991) that the weakening of frequent and extreme fluctuations in the levels of mortality is a magnificent marker distinguishing pre- from post- industrialization mortality trends.

Nevertheless, as mentioned in the chapter of theoretical model, even though Brenner's model received quite many disputes, and have been modified by the results in this study, yet a comprehensive theoretical foundation is still lacking for such study in the secular developed nations. Moreover the models employed in this study dose not include any other synthetic variables, such as environmental, political and non-economic factors, and, additionally, varied causes of death have not been defined due to the limitation of the data series, which are all likely to be candidates of the determinants of mortality trends and fluctuations. Therefore, without a comparison of the significance with other potential variables, it can be hardly to assert that unemployment is not a (*major*) determinant of mortality during the economic crisis. Nonetheless, one can conclude that, based on the present results, real GDP per capita seems like a more preferable explanatory variable to unemployment rate. Finally, without a well-established longitudinal data set available, it would be impossible to permit a sophisticated conclusion that unemployment increase or decline in real GDP per capita would not deteriorate human well-being and, in turn, increase the morbidity and mortality even if in well-developed countries.

5.2.2 Fertility

Many early studies have reached consensus that fertility does respond to economic crisis pro-cyclically, such as the Dutch famine of 1944-45 and the China great leap forward which all constitute significant fertility loss. These findings are indeed in line with the Malthusian framework. Fertility in the contemporaneous developed countries, however, is basically determined by demand side factors as children are regarded as consumer goods. According to the standard new home economic model, fertility response to the economic changes is supposed to be pro-cyclical; the better economic condition leads to high demand for children, and, in turn, fertility increase. Nevertheless, such positive association has been barely asserted since 1950s due to the idea of opportunity cost of childbearing has been introduced. There is certain inconsistency not only across the countries, but also the different periods. Hence, the fertility response to economic fluctuations and crises has become controversial.

The regression coefficients of vital rates and short-term economic fluctuations for

both Sweden and Japan, illustrated in Table 5.1 and Table 5.2 reveal very little evidence to support the hypothesis that the annual variation in fertility is strongly associated with the fluctuations in real GDP per capita and unemployment rate. One possible explanation, as discussed in 2.1.2, could be that in these well-developed nations, birth rate has already reached lowest-low level, and its recovery is unlikely to occur during the economic upswings because of the raising opportunity cost of childbearing, thus fertility response has been rather mitigated in contrary to the relative poor settings with high fertility level. Moreover, an immediate counter-cyclical response to real GDP per capita is detectable in the regression results for Japan as shown in Table 5.2. One might evidently imply that such quick fertility loss is possibly attributable to widely used contraceptive methods and increasing number of induced abortions, however this kind of conclusion is impossible to be drawn with the present available information. Additionally, such evidence clearly rejects part of the Malthusian theory and many old studies concluded that fertility response was pro-cyclical.

Although fertility responses with one year delayed to different levels of real GDP growth are not statistically significant at all, there is still some noteworthiness. First of all, results with one year of lag for the two countries indicate no significance towards the GDP growth category of "extreme low", which suggest that severe crisis does not significantly affect the birth rates. Furthermore, going from "low" to "high" level of real GDP growth, fertility responses in Sweden reveal a negative slope as illustrated by dash lines in Figure 5.2. Similar slope is also detectable in Figure 5.4, as presented by the dash line from "low" to "very high". These evidently suggest a counter-cyclical pattern of fertility in both countries, increase during economic slowdown and decline at the onset of the recovery and booming. Such finding also generates somewhat consistency with the negative relation between investment ratio and total fertility during the period between 1975 and 1999 (Stanfors, 2005). In addition, similarly to non-infant mortality, the association between extreme high unemployment and general fertility is with no significance in the two countries at all.

In summary, first of all, population in modern developed societies are far beyond the subsistence level, hence severe crisis is unlikely to induce fecundity loss and, in turn, affect the natural fertility like what happened in the Dutch famine and China great leap forward. Secondly, the lowest-low level of birth rate in the industrialized world might be responsible for the weakening fertility response to economic changes, both short-term fluctuations and severe crisis. Moreover, the raising opportunity cost of childbearing further depresses the birth rate during the good economic conditions, and therefore as discussed in 2.1.2 that recovery is unlikely to occur, as a result, the pro-cyclical effects have disappeared. Alternatively, counter-cyclical response seems the likelihood from the episodes of economic slowdown to recovery and booming. The last, but equally important, is that with a wide availability of contraceptive methods, such developed countries are more likely to sustain the lowest-low fertility for a long period, thus the frequency and magnitudes of the oscillation of fertility rate could be muted or disappeared. All of these mentioned above might contribute to the less impressive association between fertility and economic changes in the contemporary developed countries comparing to the historical world.

6 Conclusion

Economic crisis can have pronounced impacts on demographic change in the short-run, like the great depression in the 1930s, during which, population growth had reached its lowest level since the 1880s, and such population loss might be attributable to increase in mortality and decline in fertility in the crisis (Lee, 1990). Not only do mortality and fertility respond to extreme hardship, but also to short-term fluctuations as Lee (1990) claimed that both fertility and mortality respond to economic fluctuations. Although many shared patterns of demographic responses have been generalized in the historical and some less developed third world populations, they remain obscure, controversial and inconsistent in the contemporary industrialized countries.

There is a recurrent idea of the secular population that the frequent and sharp fluctuations in the levels and age patterns of mortality have been weakened, and which is an important marker distinguishing the mortality trends in modern world from historical society. Hence, it is not surprising that little evidence were found in this empirical study to support the hypothesis that the variation in mortality is strongly and positively associated with the economic fluctuations. The episodes of crisis as measured by real GDP per capita with negative annual growth does reveal some significant relation with human well-being. Nonetheless, the results in Sweden are strongly against part of the Malthusian theory as the negative GDP growth leads to a mortality decline by 0.6 per thousand, and in Japan, even though the lethal effects were detected and the pattern of the mortality response is in line with Lee's summary, the magnitude of such mortality increase in Japan is much less impressive than in the past, hence it can barely draw any magnificent conclusion that economic depression would lead to massive mortality increase like what could happen in historical population and agrarian society. The extreme high rate of unemployment as another indicator of the crisis episodes does not have any significant impacts on mortality in Japan, and which appear positive effects in Sweden as mortality rate was driven down by the run of high unemployment. Therefore, the evidences are clearly standing on the opposite of Brenner's assertion and generate agreement upon some other studies which have an important regard that economic crisis and structural adjustment typically have not led to an increase in mortality (Hill and Pebley, 1988).

Not only is the appearance of the lowest-low fertility in many well-developed countries such as Sweden and Japan, but also insufficient recovery under good economic circumstances is largely responsible for eliminating the frequency and magnitude of oscillations in the long-term fertility trend. It would be not surprising that natural fertility response has very much weakened in the modern developed world as there is no likelihood that fecundity loss would be induced by severe crisis like the Dutch famine and China great leap forward since population are far beyond the subsistence level today. Moreover, certain counter-cyclical responses are discernable in both countries which have further confirmed some recent idea that the opportunity cost of childbearing becomes much heavier in the economic upswings than downswings as the increasing participation of women in the formal labor market, thus, as a result, fertility response is likely to be transformed from pro-cyclical to counter-cyclical. All in all, it is clear that there is too little evidence to maintain the preventive check in the Malthusian framework and support the pro-cyclical hypothesis.

In summary, the present study and many other existing ones are mixed assessment about the demographic responses to economic fluctuations and crisis, but there is very rare evidence supporting the hypothesis that fertility decline and mortality increase would be widespread during the economic downturn in the secular advanced economies. Even though in some less developed Latin American countries, fertility and mortality do not seem to have been affected at all (Mason, 1997). The aggregate data series of vital rates employed in this study demonstrate considerable small variations from year to year, which are partially responsible for a few insignificant coefficient estimates.

Nevertheless, it would be a mistake to conclude that high unemployment rate and negative growth in real GDP per capita have no impact on mortality and fertility. There are several important limitations of this study. First of all, the length of the data series is not sufficiently long, which prohibit the model to include more explanatory variables and higher order of lags. Secondly, some important determinants are unavailable such as government health care expenditure, climate, environmental and political factors, etc. Finally, the current pathological causes of deaths are much more varied than in the past, and couple's attitudes and behavior with reference to fertility are quite distinguishable nowadays, furthermore, there is a huge variety of individual experience during the economic fluctuations and crisis, e.g. jobless vs. employed, real wage increase vs. loss, etc. these may cause people having different ideological and behavioral changes, unfortunately, aggregate time series data does not permit such investigations. More importantly, such problems encountered here can be only resolved by longitudinal studies of individuals and thereby provide more accurate insights. For example, if the vital rates can be further broken down for those who did and did not experience unemployment, it would be possible to precisely test whether unemployment adversely affects the demographic behavior, which, however, demands a longitudinal data set to estimate separate equations for the two groups.

My view of the crisis occurred in Sweden and Japan during the 1990s may be considerably different from some other well-developed countries, and conclusion drawn by alternative approaches. Hence, there is a large room for future researches. First of all, one could focus on the varied causes of deaths and motivations of birth control and regrouping the factors that are more consistent with theories. Secondly, it would be plausible to enlarge the samples size, not only the length of the data series, but also the wide range of areas so as to explore the variability of patterns in the different periods and continents. Third, by looking at the response of fertility and mortality to economic recovery, if there is any, would provide important clues to the social costs of previous economic crisis. Finally, but equally important, longitudinal studies are indeed capable to overcome the inherent shortcomings of aggregate time series studies, and provide the possibility of getting the dynamic insights of varied demographic responses to actually changes in standards of living of different social classes. Therefore it is necessary to be put on the research agenda, although which are relatively expensive as requiring large sample sizes and repeated subject contacts and interviews.

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Appendix

Appendix 1: Annual Economic and Demographic Data, Sweden 1970-2007

Year	Real GDP per capita (in Thousand Swedish Kronar)	Unemployment	Non-infant Mortality	General Fertility
1970	21.21251	0.014	0.0098	0.06
1971	22.73318	0.02	0.01	0.062
1972	25.16014	0.02	0.0102	0.061
1973	27.76254	0.019	0.0104	0.06
1974	30.32693	0.015	0.0104	0.06
1975	35.50924	0.014	0.0106	0.056
1976	39.80919	0.012	0.0109	0.053
1977	42.78777	0.012	0.0106	0.052
1978	48.11369	0.016	0.0107	0.05
1979	55.26475	0.015	0.0109	0.051
1980	59.14569	0.014	0.011	0.051
1981	65.44724	0.018	0.011	0.049
1982	73.9351	0.025	0.0108	0.048
1983	82.60847	0.028	0.0108	0.047
1984	93.28441	0.028	0.0108	0.048
1985	101.9597	0.026	0.0112	0.05
1986	114.8373	0.025	0.0111	0.051
1987	124.1016	0.022	0.011	0.052
1988	132.7388	0.017	0.0114	0.055
1989	145.2762	0.016	0.0107	0.057
1990	152.4772	0.019	0.011	0.06
1991	165.0786	0.021	0.0109	0.06
1992	174.9857	0.057	0.0108	0.06
1993	171.8391	0.104	0.011	0.057
1994	186.3613	0.103	0.0104	0.055
1995	199.7869	0.101	0.0106	0.051
1996	208.3643	0.095	0.0106	0.047
1997	216.7151	0.086	0.0105	0.045
1998	227.6993	0.067	0.0105	0.045
1999	238.4948	0.064	0.0107	0.044
2000	250.7894	0.053	0.0105	0.046
2001	254.9808	0.044	0.0105	0.046
2002	264.9264	0.042	0.0106	0.048
2003	274.9937	0.049	0.0103	0.05
2004	290.1334	0.055	0.01	0.05
2005	300.8051	0.053	0.0101	0.05
2006	313.9097	0.046	0.01	0.052
2007	326.4666	0.035	0.01	0.052

Appendix 2: Annual Economic and Demographic Data, Japan 1971-2006

Year	Real GDP per capita (in Japanese Yan)	Unemployment Rate	Non-infant Mortality	General Fertility Rate
1971	734965.7	0.012	0.0066173	0.068
1972	835619.8	0.014	0.0064593	0.0689
1973	937995.9	0.013	0.0066087	0.0698
1974	991089.4	0.014	0.0065269	0.0675
1975	1202785	0.019	0.0063673	0.063
1976	1365502	0.02	0.0063029	0.0606
1977	1524452	0.02	0.0061224	0.058
1978	1730159	0.022	0.0061154	0.0564
1979	1863181	0.021	0.0060076	0.0541
1980	1921546	0.02	0.006245	0.0519
1981	2109311	0.022	0.006178	0.0503
1982	2244732	0.024	0.006063	0.0499
1983	2339565	0.026	0.0062588	0.0496
1984	2470987	0.027	0.0062193	0.0488
1985	2621264	0.026	0.0062805	0.0468
1986	2768488	0.028	0.0062319	0.0451
1987	2887281	0.028	0.0062071	0.0438
1988	3055001	0.025	0.0065232	0.0426
1989	3204801	0.023	0.0064616	0.0402
1990	3407007	0.021	0.0066994	0.0392
1991	3612932	0.021	0.0067575	0.0393
1992	3761245	0.022	0.0069531	0.0389
1993	3796985	0.025	0.0071106	0.0384
1994	3843998	0.029	0.0070718	0.0402
1995	3893755	0.032	0.0074236	0.0387
1996	4015720	0.034	0.0072006	0.0394
1997	4012470	0.034	0.0073206	0.039
1998	3963482	0.041	0.0074897	0.0399
1999	3998374	0.047	0.0078372	0.0397
2000	4047074	0.047	0.0076673	0.0408
2001	3960523	0.05	0.0077305	0.0408
2002	3925607	0.054	0.0078009	0.0406
2003	3929279	0.053	0.0080524	0.0399
2004	3951721	0.047	0.0081541	0.0398
2005	4003569	0.044	0.0085968	0.0384
2006	4047977	0.041	0.0086177	0.0401