THE HEALTH INCOME HYPOTHESES TEST IN TAIWAN

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Abstract

The motivation for this thesis is the investigation of the socioeconomic determinants of health in Taiwan. When considering the variations in socioeconomic status, income is an indicator much discussed in the literature because it is a complex issue and yet easily measured. Many different economists investigate income issue from the perspective of their own particular expertise. For health economists, the influence of income on health outcome is primary. Therefore, many health income hypotheses have been advanced and the debate is ongoing.

Among these hypotheses, the absolute income hypothesis, the relative income hypothesis, and the income inequality hypothesis are discussed primarily. The argument of these hypotheses is straightforward. The debates of these different hypotheses are based on two main dimensions, economic development and data. The advocates of the absolute income hypothesis claim that absolute income affects health significantly. The advocates of the relative income hypothesis or the income inequality hypothesis, however, argue that the absolute income hypothesis holds principally before a society moves to an affluent stage. After economic transition, the relative income or income inequality hypothesis becomes more influential.

Wilkinson and Pickett (2006) summarize the conclusions of 169 papers relevant to the relative income hypothesis and income inequality hypothesis and find a phenomenon that the studies using large area data are more likely supportive than those using small area data. They argue that income inequality in large area is a good measure of the scale of social stratification or the degree of social hierarchy rather than in a small area. Another argument to explain this phenomenon is aggregate bias proposed by Gravelle et al. (2002).

The thesis tries to find the answers for the following questions. What income hypotheses hold for Taiwanese society? Do these hypotheses coexist or are they mutually exclusive? Is aggregate bias a negligible issue in Taiwan when aggregate data are used to infer individuals' health income relationship?

Chapter 3 combines aggregate data and individual data and creates a panel dataset to examine the absolute income hypothesis and the income inequality hypothesis. The motivation is to avoid aggregate bias. Chapter 4 employs nonparametric estimations to describe the relationship between health outcome and income and compares the results of parametric estimations and of nonparametric estimations. Chapter 5 utilizes the quasi-experimental methods to identify the absolute income effect on health outcome.

The nonlinear relationship between a) self-assessed health, b) depression, c) life satisfaction and income is found in chapter 4. This finding implies that in the Taiwanese studies the aggregate bias needs to be considered when aggregate data are used to infer individual health income relationship and it is consistent with the motivation of the proposed approach of combining aggregate data and individual data in Chapter 3. The difference between parametric estimations and nonparametric estimations is not only shown in the figures but the model specification test also shows that the parametric linear, quadratic, and cubic forms in terms of income are a misspecification in the estimations of depression and life satisfaction.

The absolute income hypothesis and the income inequality hypothesis are supportive in this thesis when long-run income and long-run Gini coefficient are the regressors under the assumption of health social gradient. This finding shows that health income hypotheses are not contradictory. Chapter 5 also provides evidence to support that long-term income has a significant effect on mental health. Thus, the absolute income hypothesis is also supported after taking causality into consideration.

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Contents

Table Contents

Figure Contents

Chapter 1. Introduction

1.1 Introduction

Health constitutes a cornerstone of economic growth and as such it has an enormous impact on labour productivity and on the accumulation of human resources. For instance, healthy individuals would probably receive more education and achieve higher productivity than sick individuals. Health is at once a broad and complex issue. Social scientists investigate health from multiple angles, for example, health promotion, public health, sociology, and psychology. Economists are interested in all factors affecting health and use theoretical models and econometric methods to analyse the determinants of health. Among various determinants, socioeconomic status is an accepted determinant affecting health whether through direct ways or indirect ways. Among numerous socioeconomic status, income and wealth relevant determinants attract considerably interest of researchers.

Income and wealth influence health through several pathways, for example, health care service, financial stress, and social comparison. Income can facilitate access to better health service and increase health investment to improve physical health as well as relieving the financial stress to improve mental health. On the other hand, income and wealth are typical symbols of socioeconomic status so they are also a tool for social comparison. Social comparison is not always negative but an invidious comparison may cause the mental stress and further, harms the mental health. These pathways might coexist no matter at what stage of economic development. At the developing stage, people are struggling to escape from poverty so that the pathway of social comparison might not be as significant as the other pathways. Income is a main determinant of health at this stage. Thus, absolute income might have a significant effect on improving physical health (through health care service and health investment) and mental health (through health care service and the relief of financial stress).

At the developed stage, the cost of utilizing health care service is relatively low because of the high average income level and the implementation of social schemes relevant to health which have covered most medical expense. The basic health care service is secured, and thus, health care service might not be the most essential factor of health outcome. In an affluent society where the media is flourishing, the pathway of social comparison might have more influence on health. For example, media broadcasting luxury goods changes people's values. The commercial media encourages people to pursue anything representing their socioeconomic status. This might cause stronger comparison behaviour. Clark and Oswald (1998) and Clark and Senik (2010) have the theoretical discussion of social comparison. Though the pathway of social comparison is stressed at this stage, income level still possesses the function of relieving stress but this stress might come from pursuing high quality life instead of financial embarrassment.

Three main health income hypotheses discussing the relationship between income and health are 1. the absolute income hypothesis; 2. the relative income hypothesis; 3. the income inequality hypothesis. Money can not only buy nutritious food and good quality health services but can also bring a sense of security and, further, reduce depression or other mental stress. This is the argument of the absolute income hypothesis - income is able to improve health status. The relative income hypothesis claims that individuals tend to emphasize their relative income more than absolute income amount due to the comparison when a society reaches an affluent stage. Finally, the argument of income inequality is income inequality becomes a more important determinant of health than absolute income when a society has higher average income (after epidemiological transition). Income inequality influences health through social environment. Apart from three main hypotheses, there are other health income hypotheses such as the deprivation hypothesis and the relative position hypothesis but the aforementioned three health income hypotheses are the subject of most discussion and the conclusions are not consistent.

The data used in the analysis are one of the reasons causing the mixed results. Wilkinson and Pickett (2006) sort out 169 studies relevant to income distribution and find that the Gini coefficient measured at different regional levels affects the result of the income inequality hypothesis test. The Gini coefficient measured over a large area tends to support the income inequality hypothesis. Conclusions drawn from a small area do not yield much evidence to support it. They claim that the Gini coefficient is a good measure of the scale of social stratification over a large area rather than small area. However, Gravelle et al. (2002) think this circumstance results from aggregate bias caused by nonlinear individual health income risk and improper aggregate variables replacing individual variables. Understanding the real individual health income relationship can produce a clear conclusion in terms of different income hypotheses and at once explain income related health inequality.

This thesis uses Taiwanese survey data to test two main health income hypotheses, the absolute income hypothesis and the income inequality hypothesis, and to draw the individual health income relationship. Taiwan has been categorized as a developed country by the International Monetary Fund (IMF) since 1990s. Taiwanese government has implemented several social insurances such as Labour Insurance, Military Insurance, Government Employee Insurance, and Farmer Health Insurance for decades. Those occupational insurances also cover medical expenditure so the basic health access is secured. In 1995, the government carried out the National Health Insurance (NHI) which integrated the medical payment of occupational insurances and included the people who were not covered by those occupational insurances. There were 96.2% of population covered in 1998 and it achieved 99% in May 2010. The satisfaction of NHI approximated to 80% recently. Comparing Taiwanese health policies to other advanced countries' health policies, it is largely identical but with minor differences. However, in the process of development, Taiwan is different from western countries in two aspects. Firstly, fast development comes with low income inequality. In 1980s, Taiwan's economy highly developed and the Gini coefficient was lower than that of western countries though it went up rapidly. To date, Taiwan's income inequality is still low compared to the other advanced countries. Secondly, Taiwan has higher savings ratio than the other advanced countries. Even when the real income decreases, the savings ratio still keeps at the same level. High savings ratio implies the lack of sense of security and uncertainty for the future such as macroeconomic and politic situations, job markets, and inflation. When people are pessimistic about their future, money is the means offering the sense of security.

Chiang (1999) uses Taiwanese survey data to test the absolute income hypothesis and the income inequality hypothesis by regression analysis of mortality on income and income inequality for three index years, 1976, 1985, and 1995. The data used in his article is Family and Expenditure Survey and Taiwan-Fukien Demographic Fact Book which reports various mortality rates annually. He claims that the population health is affected by income inequality more than by absolute income after Taiwan past the epidemiological transition. This thesis is based on the argument of aggregate bias and starts from refining Chiang's analysis with the same socioeconomic data but different mortality data. Chapter 3 tests the absolute income hypothesis and the income inequality hypothesis by combining aggregate mortality data and individual socioeconomic status data. The panel dataset is created at county level. This approach allows use of the county panel dataset to avoid aggregation bias. Chapter 4 utilizes nonparametric methods to estimate individual's health income relationship for two reasons. First, nonparametric methods can avoid the potential problem of misspecification. Secondly, these methods display clearly the variation of health across different income levels to figure out income related health inequality. If the relationship is nonlinear, it will support the analysing strategy in Chapter 3 and produce more precise results because it avoids the problem of aggregate bias whereas, if the relationship is linear, this will imply that aggregate bias is not an issue in the hypotheses test when one uses aggregate data and the result obtained from Chapter 3 will be theoretically the same as that obtained from analysis of aggregate data. Chapter 3 and Chapter 4 discuss health income relationship under the assumption of health social gradient – a negative relationship between health indicators and socioeconomic status and the direction goes from socioeconomic status to health. Given potential reverse causality, Chapter 5 uses an explicit identification strategy to identify the effect of absolute income on health by evaluating the policy effect of the Senior Farmer Welfare Benefit Interim Regulation on health as the robust evidence for the test of absolute income hypothesis.

Before proceeding to the main points of discussion, the following sections in this chapter introduce the Taiwanese background, especially, the development of the economy, the education system, and the social welfare for several reasons. First, the relative income hypothesis and the income inequality hypothesis claim that people are concerned about their relative income more than their absolute income after economic transition. To describe the economic development can help readers to understand at what economic stage Taiwan is in the period of analysis. Second, education is one of the measures of socioeconomic status and the positive association between education and health is well established (Feldman et al., 1989; Morris, 1990; Winkleby et al., 1992). The introduction of measures of education transition can reveal partially the variation of socioeconomic status and the circumstance of social mobility in Taiwan. Finally, the introduction of social welfare policies is useful as background to a detailed picture of Taiwan's social welfare system for the investigation of chapter 5.

1.2 Economic Transition

After World War II (WWII), economic depression spread to the Far East including Japan, China, Korea Republic, and Taiwan. The subsequent economic development of Japan and Taiwan has attracted the interest of researchers because of the fast growth in the 50 years after WWII. Hence, there is a lot of literature investigating the Japanese and Taiwanese economies. After WWII, Taiwan's economic development can be roughly partitioned into four periods, the economic recovery period (1949-1952), the period of agriculture supporting industry (1950s), the period of export-oriented economic development (1960s-1980s), and the economic transformation period (1980s-present).

1.2.1 Economic Recovery Period (1949-1952)

In this period, booming population, soaring prices, stoppages in industrial and agricultural production and military expenditure which accounted for more than half of government expenditure resulting in severe social problems and economic collapse. To address these problems, the Taiwanese government adopted a series of policies and measures, for example, land reform, currency reform, foreign trade control, the first priority to develop electricity, fertilizer and textile industries, to stabilize the society and economy. In the 1950s, the growth rate of agricultural industry achieved approximately 4.7% every year. Further, in 1950, economic aid from United States injected substantial funds. For these two reasons, the economy of Taiwan was restored and it recovered to the highest level before WWII.

1.2.2 Period of Agriculture Supporting Industry (1952-1960)

Taiwan's economy was largely based on agriculture so that there was an excess labour force. Meanwhile, the foreign trade deficit was serious and foreign exchange was in short supply. The import of industrial products was not affordable because of low income levels. Hence, the government established policies whereby agriculture supported industry and industry improved agriculture. Land reform improved agricultural productivity so that agricultural products and processed products constituted a very high proportion of total exports and became the main source of foreign exchange[1]. The Government also used the profit acquired from compulsory acquisition and other means, for instance, unequal exchange, to inject into industrial development. In industry, the focus was on livelihood industries based on less capital requirement and lower technology to replace imports. On the other hand, the government curtailed foreign exchange spending and created more employment opportunities to alleviate employment pressure.

1.2.3 Period of Export-Oriented Economic Development (1960s-1980s)

Due to the small market, the market for import substitution industries was at saturation point. Meanwhile, the greater specialization as an industrial rating was advocated. Taiwan seized the advantage to develop export processing industries by using a low-wage labour force to promote economic development. On the other hand, the government also formulated or amended policies such as the reform of foreign exchange and trade, implemented investment incentive regulations, encouraged private savings, tax and financing benefit for exporters, and established export processing zones and bonded warehouses to promote exports. Foreign investment during this period of industrialization

[1] For example, it achieved 71.5% in 1957.

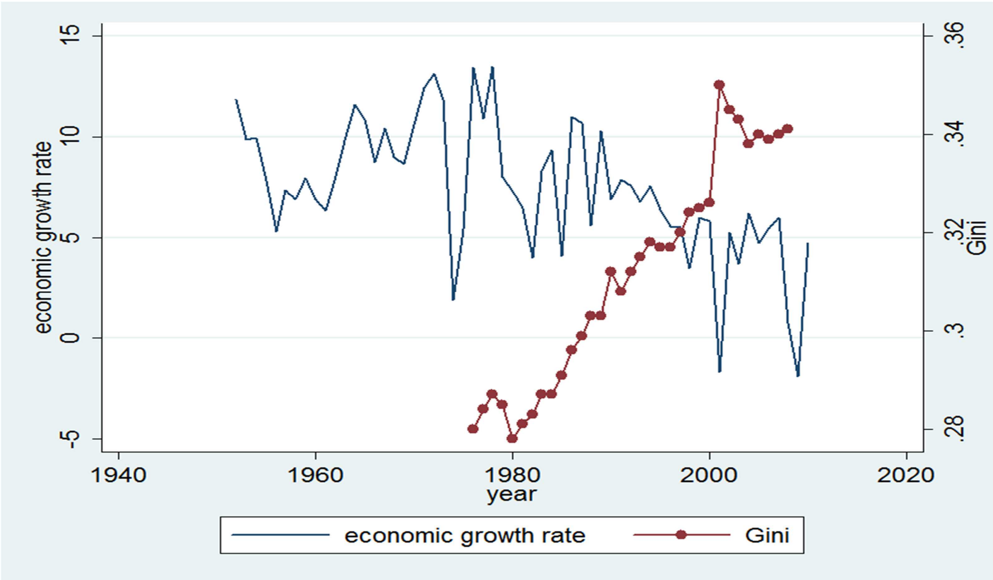
and export expansion in Taiwan played an important role. The private sector industries changed from import substitution to export. This was the main force of economic growth. Japan, the United States, and Taiwan had triangular trade relations, importing raw material from Japan and exporting products to the United States. During the decade from 1963, the average annual growth rate of industry was 18.3% while the average annual growth rate of the manufacturing sector achieved 20.1%. Industrial output in GDP increased from 26.9% in 1960 to 43.8% in 1973. The proportion of industrial production in exports increased from 32.3% in 1960 to 84.6% in 1973. Taiwan's industry was based on export processing zones and used textiles, home appliances and other processing industries as the core to drive economic development.

1.2.4 Economic Transformation Period (1980s-present)

In the 1980s, Taiwan’s internal and external economic environment changed. The NT dollar exchange rate appreciated and wages rose sharply. Labour-intensive export processing industries lost their comparative advantage which lead to a drop in private investment. The economy suffered from hardship. For these reasons, in 1986, the government started economic transformation with liberalization, internationalization, and institutionalization to improve and perfect the market economic mechanism. Meanwhile, industrial upgrading and expansion of foreign markets outside the U.S. underwent a major adjustment. After a decade of economic transformation, capital and technology-intensive industries account for 61.5%.of manufacturing industry. The information industry was particularly prominent and its output ranked highly in the world. Taiwan's foreign export market focus had gradually shifted from Europe and the United States to Asia. The proportion of exports to the U.S. sank from 48.8% in 1984 to 23.7% in 1995 and exports to Asia increased from 32.8% in 1988 to 52.6% in 1995. Export structures also had changed greatly. Electronics, information, mechanical, electrical and transport products accounted for more than 50% of total exports. Due to the substantial growth of foreign investment, Taiwan had become a net capital exporter. The accumulation of Taiwanese foreign investment was approximately 30 billion U.S. dollars in 1995.

Taiwan's so-called economic miracle has resulted in not only faster growth but also less income inequality than elsewhere especially before 1980. Figure 1.1 displays the economic growth rate over the years and the historical Gini coefficient. After 1980, the

Figure 1.1 Economic Growth Rate and Gini Coefficient



Gini coefficient went up continuously and it crossed 0.3 in 1988 whereas the economic growth rate dropped gradually after 1994. Although the variation of Gini went up, it was still under 0.4.

1.3 The Transition of Education

General education and vocational education are the two main components in the Taiwanese education system. The duration of schooling from primary school to university is 16 years in total. The primary school and junior high school which are 9 years in total have become compulsory education since 1968. Before 1968, only primary school was compulsory. After the period of compulsory education, students have to take the joint entrance examination for further education.

Before 2001, students had to take the joint entrance examination after they graduated from junior high school if they wanted to continue their study. Students had three options which are the general senior high school (3 years), five-year junior college, and vocational senior high school (3 years). The latter two options belonged to vocational education. The entrance examinations for these three kinds of school were separated and held in July every year. After senior high school, students who had graduated from general senior high school had to pass the joint entrance examination for enrolling at university (4 years) if they wanted to accept high education. Another option for these students was three-year junior colleges but it was abolished step by step in 1980s. The students graduating from vocational senior high school had to pass the joint entrance examination for going to the four-year institute of technology or two-year junior colleges. The options for students after five-year junior college included two-year vocational college and university. After university or equivalent degrees, students had to pass the entrance examination for postgraduate study. At least two years are for master and at least 4 years are for Ph. D. Figure 1.2 illustrates the education system in Taiwan

Due to the complicated processes of entering further education, education policies for high schools were changed in 2001. After 2001, the basic competence test replaced the aforementioned entrance exams and this exam is more standardized[2]. This exam is now held twice per year. Students get one more opportunity to pass the exam. High schools

[2] Before 2001, the exams of entrance for three kinds of school were different and each exam was also different from region and region.

including general and vocational school and five-year junior colleges can admit students according to the result of basic competence test and other criteria made by individual school. The purpose of this change is to simplify the entry process.

After 2002, the multi-route promotion programme replaced the conventional united exam of entrance of university in order to provide more routes for high school students to access higher education. On the other hand, several five-year junior colleges were promoted to four-year institutes of technology in 1996 and further, were promoted to universities of technology gradually after 1996. The universities of technology can not only admit students from vocational senior high school but also general students.

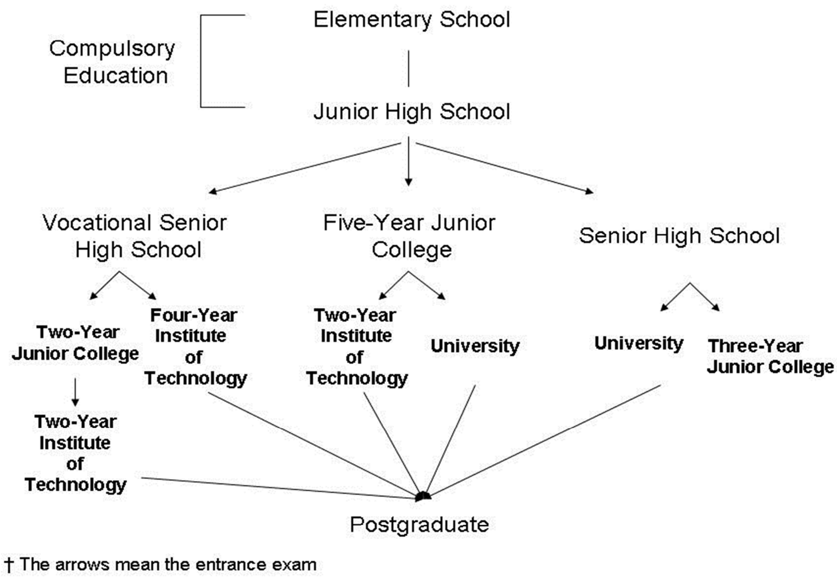
The most critical thing in the previous education policies is that students had only one route which was the joint entrance exam held once every year to access higher education. Thus, broadening the entrance route is the purpose for the policy change. Not only the entrance exam but also application and promotion are the routes to enter further education in the new education polices.

Higher education was an elite sector before the policy change, especially before the 1980s. Less than 20 percent students could enrol in universities. The enrolment rate increased gradually. It achieved 50% in 1997 and it is 100% now. The 100% enrolment rate results from the increasing number of universities and from the falling fertility rate. The total number of institutes classed as university or equivalent level in Taiwan is 164[3].

[3] The population in Taiwan is 23 million and the territory is around 1/7 of Great Britain.

The rising university enrolment rate causes a few problems, for example, distorting the allocation of human resource and reducing the return of education. However, it guarantees the human right of education and improves social justice. In a word, the changes of education policy in the late 1990s make education more available. Higher education becomes general education rather than elite education.

Figure 1.2 Education System of Taiwan



1.4 The Historical Perspective of Social Welfare Policies

Social welfare is provided by government whether directly or indirectly and it covers three dimensions, economic status, health, and mental status. Social welfare can not only provide security in people's lives but also be an indicator of development. Developed countries usually have more comprehensive social welfare because it needs a large budget to support. In social welfare, social insurance is the main structure in the system because it nearly covers three dimensions mentioned above. On the other hand, benefit and social assistance are auxiliary tools to support the inadequacy of social insurance or achieve social justice. The following paragraphs introduce the social insurance and benefit policy in Taiwan.

Medical payments and retirement pension are two main components in social insurance. Before the implementation of National Health Insurance (NHI), there were five comprehensive and several health insurance schemes. The five comprehensive schemes comprise labour insurance (LI), government employee insurance (GEI), farmer insurance (FI), teacher insurance for private school (TIPS), and retirement insurance (RI). LI, implemented in 1950, was the first insurance scheme. In the same year, military insurance (MI) was also implemented. GEI, RI, and TIPS were introduced in 1958, 1965, and 1980, respectively. However, RI is part of GEI because it is provided for retired government employees but it is not compulsory. The government selected a few areas to implement FI in 1985 and it was implemented in the country in 1988. However, this was just an experimental scheme. Due to the favourable effect, FI was formally implemented in 1989. Even though there were many health insurances before implementation of NHI, some people were still not covered. NHI was enacted in 1995. It merged the section related to medical payments of social insurance schemes and, at the same time, it also provided a medical security for those who were not covered by any social insurance.

Apart from the comprehensive insurance schemes, the other programmes were abolished after the government implemented NHI. In 1999, GEI and TIPS were merged into the government employee and teacher insurance scheme (GETI). Generally speaking, the three main comprehensive insurances (LI, GETI, and FI) only do the business of retirement pension and other non-medical payments after NHI. In 1999, the government implemented a regulation of unemployment payment of labour insurance to provide economic security for unemployed labours in the first 6 months. However, this regulation was abolished in 2003 and replaced by the Employment Insurance Act (EIA). Further securities and assistances are included in this Act.

The pension, especially the retirement pension, provides senior citizens with basic security to avoid suffering from extreme poverty. However, FI is the only job-related insurance without a retirement pension. In view of this, the government granted senior farmer benefit in 1995 to compensate the inadequacy of retirement pensions in the FI. This will be discussed further in Chapter 5. However, the idea of benefit is different from the concept of pension. Despite the three job-related insurances covering the majority of the population, the unemployed and those outside the labour force are not covered by any pension scheme. For this reason, the government enacted the National Pension Scheme (NPS) in 2008. The National Pension Scheme is also a compulsory scheme. An individual who is at age 25 and older and is not included by three job-related insurances has to participate in the national pension scheme until 65 years old if they are not covered by any other job-related insurance during this period.

With respect to benefits, they are usually provided for senior citizens. Apart from the senior farmer benefit, the government granted benefit in 1998 to senior citizens in the low or middle income quantiles. The Government also introduced the Senior Welfare Benefit Interim Regulation (SWBIR) in 2002. However, not every senior citizen is eligible to claim this benefit. One has to meet some qualifications to receive the benefit. In 2003, it covered 30% of senior citizens. The Senior Farmer Welfare Benefit Interim Regulation was abolished after National Pension Scheme was implemented. People who participate or had ever participated in National Pension Scheme are eligible to claim this pension no matter that they claim retirement pension from other insurance schemes. In order to look after disabled senior citizens in low or middle income families, the government introduced regulations on special care benefit to grant the benefit in 2007. Again, these issues will be important for the discussion in Chapter 5.

As for social assistance, the government implemented the Public Assistance Act in 1980. The target of this Act is people in the lowest income quantile or with disabilities. It provides mainly economic assistance. There are many other regulations allowing the disabled to secure job opportunities and provide them with other forms of assistance.

Social insurance, the benefits system, and social assistance constitute a comprehensive programme of economic social security. They provide security to people suffering from extreme poverty and maintain basic human rights. Table 1-1 illustrates the development of social welfare in Taiwan.

1.5 Conclusion

This thesis is organized as follows: Chapter 2 introduces the previous literature related to health income hypotheses. Chapter 3 tests the absolute income hypothesis and the income inequality hypothesis by combining aggregate and individual data. Chapter 4 investigates the health income relationship with nonparametric estimations. Chapter 5 retests the absolute income hypothesis with quasi-experimental methods. Finally, Chapter 6 is the conclusion.

Table 1-1 The Development of Social Scheme in Taiwan

Year	Scheme	Notes
1950. 3	Labour Insurance	Labour Insurance Regulation of Taiwan Province was the source of law. Act of Labour Insurance was formulated in 1958.
1950. 6	Military Insurance	Regulation of Military Insurance was formulated in March of 1950.
1958. 9	Government Employee Insurance	Act of Government Employee Insurance was announced in January of 1958.
1965. 8	Retirement Insurance	Regulation of retirement insurance was announced in March of 1964.
1980. 6	Low and Middle Income Family Living Allowance	Public Assistance Act was the source of law and announced at the same time.
1980. 10	Private School Teacher and Staff Insurance	Regulation of private school teacher and staff insurance was announced in August of 1980.
1984. 1	Retirement Insurance for Private School Teacher and Staff	
1985. 10	Pilot Farmer health Insurance	Farmer health insurance temporary pilot points was the source of law
1989. 7	Farmer Health Insurance	Farmer Health Insurance Act was announced in June of 1989
1995. 3	National Health Insurance	National Health Insurance Act was announced in August of 1994
1995. 5	Senior Farmer Benefit	Interim Regulation of Senior Farmer Welfare was the source of law
1999. 1	Unemployment Labour Benefit	Regulation of Unemployment Labour Benefit was announced in December of 1998
1999. 5	Government Employee and Teacher Insurance	Government Employee and Teacher Insurance Act was announced in May of 1999. This Act merged Government Employee Insurance and Private School Teacher and Staff Insurance
2002. 5	Senior Welfare Benefit	Interim Regulation of Senior Welfare Benefit was announced at the same time.
2003. 1	Employment Insurance	Employment Insurance Act was announced in May of 2002
2007. 7	Special Care Benefit for Middle or Low-Income Senior Citizens	Regulations on Special Care Benefit For Middle or Low-income Senior Citizens was announced at the same time
2008. 10	National Pension Scheme	National Pension Act was announced in August of 2007

Chapter 2. Income Hypotheses

2.1 Literature review

Understanding the determinants of health is a crucial issue in many countries because health affects the accumulation of human capital and labour productivity through education. Furthermore, it affects a country's economic growth. The vast majority of empirical papers in health economics investigate the topic of what causes the health difference between countries. Among the primary determinants, socioeconomic status is of interest to many researchers and policy makers; and income and wealth are widely discussed as former among those socioeconomic determinants. In recent decades, many health income hypotheses have appeared to explain how income affects health status.

Wagstaff and Doorslaer (2000) categorize previous papers into five income hypotheses: 1. the absolute income hypothesis (AIH); 2. the relative income hypothesis (RIH); 3. the income inequality hypothesis (IIH); 4. the deprivation hypothesis (DH) and 5. the relative position hypothesis (RPH). The latter two hypotheses are the derivatives of the relative income hypothesis. Thus, the following discussion concentrates on AIH, RIH, and IIH.

The absolute income hypothesis claims that income affects health on both physical and psychological levels. On the physical level, income increases one's ability to purchase nutritious food and to acquire better quality health service. On a psychological level, income provides a sense of economic security which results in significantly lower levels of existential stress. People who encounter financial insecurity, debt, job insecurity, and unemployment have worse health status (Bartley, 1994; White, 1991; Wilson and Walker, 1993; McGrown, 1994; Iversen and Klausen, 1981; Ferris et al., 1995; Cobb and Kasl, 1997; Mattiasson et al., 1990). Some of these papers explain that the worst health results from those factors due to the mediation of health risky behaviours, such as obesity, smoking and excessive drinking (Cameron and Jones, 1985; Wilkinson, 1996; Li and Zhu, 2006), and restricted social contact (House et al., 1998; Broadhead et al., 1983; Berkman and Syme, 1979; Whelan, 1993; Rosengren et al., 1993).

Wilkinson (1996), however, says ‘income per se does not affect health’. Income affects health through other ways, for instance, the tendency to compare income. The relative income hypothesis claims that people emphasize their relative income to others rather than their own absolute income amount after society achieves its affluent stage. The income inequality hypothesis claims that income inequality harms health through an unstable society, for example, strike, violence, crime, and even coups, which results from collapsed social cohesion and trust, and harmful psychosocial effects of invidious social comparison (Durkeim, 1951; Berkman and Syme, 1979; Muller, 1985; Kawachi et al., 1996, 1997; Kawachi and Kennedy, 1999).

Generally speaking, RIH and IIH share the common idea that the individual compares his or her own situation to others similar individuals. Relative income and income inequality influence health through comparison. From an economic viewpoint, comparison influences health directly in terms of the relative income hypothesis. People, whose income is above a specific level, have a positive health effect. People have a negative health effect when their income is below a specific level. As to income inequality hypothesis, in a society with high income inequality, invidious social comparison brings harmful psychological effects and, at the same time, erodes social capital which will cause an unstable society. For example, income inequality causes unfair allocation of resource. The resource is allocated more in affluent area or advantaged groups than poor area or disadvantaged groups. The disadvantaged people would feel deprived when they compare the benefit of resource allocation or their income to that of advantaged people. In this circumstance, social cohesion will collapse and people might lose trust in government. Furthermore, social destabilization is generated. An unstable society brings high pressure and causes uncertainty in the environment which affects health.

In the econometric approach, the definition of the different hypotheses depends on the measured variable of relative position in the analysis. For instance, if an index of income inequality is used in the analysis, the income inequality hypothesis is tested. If a relative deprivation measure is used in the analysis, it will test the relative income hypothesis.

The other hypotheses are based on the same concept of comparison, for example, comparison of socioeconomic characteristics comparison apart from income such as type of job, education, or difference in capital assets.

It is fitting at this point to question whether the tendency to self-compare constitutes is an innate trait of human cognition? If the answer is ‘Yes’, then relative inequality should not just hold in affluent countries (or in countries that have experienced economic transition) but in every country. If the answer is ‘No’, what drives human beings to compare themselves one another? Two social influences can explain somewhat motivation for such comparison. One is Informational Social Influence and the other one is Normative Social Influence. When people do not know how to behave, they copy other people’s behaviour. This pattern of behaviour is named Informational Social Influence. It provides a safe course of action. At least, other people cannot criticize practitioners of such behaviour for their action. In the case of Normative Social Influence, the fundamental factor is the human need to belong to social groups. Common beliefs, values, attitudes, and behaviour are needed. People go along with the others to avoid being perceived as a fool or a loser. Social influence might have different effect in different cultures. Collective cultures, for instance, most Asian culture, will tend to be influenced by normative social influence more than individualistic cultures.

Social comparison is a theory to model the relationship between comparison and well-being and it also provides a theoretical fundamental for the relative income hypothesis. Helson (1964) and Parducci (1968) argue that all judgments and satisfaction are relative values instead of absolute values. Hagerty (2000) analyses individual and aggregate data and concludes that subjective well-being is affected by the social comparison effect of the subject's income. He also explains that some literature does not support social comparison because the researchers only emphasize the average effect and ignore the characteristics of income distribution, such as its range and. Yngwe et al. (2003) suggest that social comparison is a mechanism in the relationship between income and health. Clark and Oswald (1998) establish an economic model to describe the relationship between the individual utility function and comparison behaviour.

In addition to the aforementioned discussion, there are a few papers discussing the relationship between other factors such as social mobility, occupation, consumer culture, and genes, life events and health (Bartley and Plewis, 1997; Karasek and Theorell, 1990; Marmot et al., 1991; Kawachi and Kennedy, 2002; Rosengren, 1993; Helsing and Szklo, 1981; Brown, 1978; Hayakawa et al., 1992a).

2.2 The Measure of Empirical Variables

2.2.1 The measure of health status

The majority of empirical literature uses death rate, life expectancy, and self-assessed health as the indicators of measuring the health status because they are the primary available indicators in most health reports and surveys. Infant mortality rate and population mortality rate are the two most used indicators in the literature. The advantage of death rate is that it is accurate and objective whereas its weakness is that it is not sensitive to detect the prevalence of everyday illness and diseases.

Life expectancy overcomes this weak point. It is computed from cardinal mortality rates and it reveals the average expected life span at every age. The flaw of life expectancy is that it is not sensitive to death rate when the death rate is small.

Self-assessed health is a direct way to understand individual's health status. Several measures such as Short Form 12 (SF-12), Short Form 36 (SF-36), and other general questions are used in the literature. The difference between these measures is the number of questions in the questionnaire. SF12 questionnaire composes 12 questions and SF36 questionnaire comprises 36 questions. In the process of dealing with SF12 and SF36, each question has a score and the total score of all questions is converted to a final score in physical and mental dimensions respectively. Another question measuring general health is: would you say your health is excellent, very good, good, fair, or poor in general? The drawback of self-assessed health indicators is that it is too hard to know exactly what the respondents mean which is very subjective. When people think their health is good, it is difficult to know the difference from those who say their health is very good. Although this weakness exists, many studies such as Wilkinson (1996), Idler and Benyamini (1997), McGee et al. (1998), and Contoyannis and Jones (2004) suggest that self-assessed health is a good predictor of subsequent mortality which does not systematically vary by socioeconomic characteristics.

Death rate and life expectancy are the national or ecological data. Many studies analysing the cross-country or cross-state data use these two indicators whereas self-assessed health is observed at the micro-level data so that it is utilized in a number of studies whose interest is on the association between health status and income at individual level.

2.2.2 The Measure of Income Inequality or Relative Deprivation of Income

How to measure income inequality or the relative deprivation of income might affect the conclusion of health income hypotheses test. Income inequality is an aggregate concept. Hence, it cannot be a measure on an individual basis.

Champernowne (1974) suggests seven criteria for a good indicator of inequality.[4] The more criteria an indicator meets, the better indicator it is. The Gini coefficient, variance, standard deviation and the ratio of upper quantile and lower quantile are frequently used as the measure of income inequality in literature. However, do different measures result in different conclusions? Kawachi and Kennedy (1997) examine 6 different measures of income inequality including the Gini coefficient, the decile ratio, the proportions of total income earned by the bottom 50%, 60%, 70% of households respectively, the Robin Hood index, the Atkinson index, and Theil's entropy and conclude that the choice of income distribution measure does not apparently alter the result that income inequality is linked to higher mortality.

According to Runciman (1996), the definition of relative deprivation refers to 'the extent of the difference between [some] desired situation and that of the person desiring

[4] 1. Familiarity and convenience for computation or estimation from statistics in a readily available form. 2. Impartiality between persons, in the sense that they depend only on the frequency distribution of income and not at all on the order in which individuals are ranked within the distribution, and thus not at all on the association of income with other characteristics such as wealth, power, political advantage, race or health. 3. Invariance with respect to the number of persons receiving income. 4. Invariance with respect to uniform increase (or decrease) of the size of income. 5. Pigou-Dalton efficiency. 6. Range from zero to one. 7. Suitability as a specialist measure of one particular aspect of inequality.

it'[5]. Eibner and Evans (2005) develop an indicator named RD to measure relative deprivation based on Runciman's definition and subsequent theory developed by Yitzhaki (1979). The equation is $RD_i = 1/N\sum_j(y_j - y_i)\forall y_j > y_i$. This measure posits that the relative deprivation of individual i is driven by the income of individual j who earns more than y_i in a reference group with N individuals. Li and Zhu (2006) construct three relative deprivation indices following Eibner and Evans (2005) as the indicator for relative income. The indices are relative deprivation of absolute income (RDA), relative deprivation of log income (RDL), relative deprivation over individual income (RDI), and individual rank. The definition of RDA is the same as RD defined by Eibner and Evans. RDL replaces income with log income in the definition of RDA. RDI is defined by RDA_i/y_i. The index of individual rank is defined by the individual's centile rank with in a reference group (where the income is sorted in the ascending order).

2.2.3 Other Characteristics

Demographic variables usually controlled for in the research are age, gender, education, marital status, and occupation. Educational attainment is a proxy for investment in human capital. The accumulation of human capital plausibly has a positive relationship with income. Education is not only a prediction of future earning but it also increases people's knowledge of avoiding health risk factors. Elo and Preston (1996) use US data and reveal the significant difference in mortality rather across educational attainment groups among men and women in the early 1980s. Mortality rates according to educational differences are larger for men than for women and larger for people at working age than for people of retired age. Winkleby et al. (1992) suggest that adult

[5] A person can be said to in the situation of relative deprivation of X when (i) he does not have X, (ii) he sees the other person or persons, which may include himself at some previous or expected time, as having X (whether or not this is in fact the case), (iii) he wants X, and (iv) he sees it as feasible that he should have X.

health behaviours such as smoking and exercise more closely associate with educational attainment than with income or occupation. Meanwhile, educational attainment is also a reflection of both family background and personal traits.

With respect to occupation, the relationship reflects a more complicated interaction of not only social classes but also income and psychosocial pathways such as stress and social networks etc. Besides these variables, geographical or ecological variables should also be taken into consideration to control for environmental effects.

2.3 Theory

Wilkinson and Pickett (2006) summarize the conclusions of 169 papers relevant to the relative income hypothesis and income inequality hypothesis and sort out those papers into three categories: wholly supportive, partially supportive and unsupportive (see Table 2-1). For example, in cross-national studies, Legrand (1987), Waldmann (1992) and Wilkinson (1992) are wholly supportive to the hypotheses whereas Judge (1995), Gravelle et al. (2002) and Wildman et al. (2003) do not find evidence in support of the hypothesis.

At the level of states, regions and metropolitan areas, the wholly supporting studies are, for example, Blakely et al. (2001), Kawachi and Kennedy (1997) and Chiang (1999). The unsupportive studies are, for example, Mellor and Milyo (2002), Deaton and Lubotsky (2003) and Henderson et al. (2004).

The wholly supporting studies using the data of small areas such as counties and neighbourhood are, for example, Soobader and LeClere (1999) and Gold et al. (2001). The opposite studies are such as Franzini and Spears (2003) and Hou and Myles (2005).

They find that majority of studies (approximately 70 per cent) suggest that income inequality worsens average health status. However, there is a phenomenon that the studies using large area data are more likely supportive than those using small area data. They argue that income inequality in large area is a good measure of the scale of social stratification or the degree of social hierarchy rather than in a small area. Another argument to explain this phenomenon is aggregate bias proposed by Gravelle et al. (2002). This thesis follows this argument.

Table 2-1 Summary of results of 169 analyses of the relation between income distribution and population health contained in 155 papers (In parentheses: homicide studies)

	Wholly Supportive Only sig. + findings	Partially Supportive Some sig. + and some null	Unsupportive No sig. + findings	Total All studies	Wholly supportive as per cent of all excluding partially supportive (%)
Level 1	30 (11)	9	6	45 (11)	83
Level 2	45 (13)	21	17	83 (13)	73
Level 3	12(2)	14	14 (1)	40 (3)	45
Total	87 (26)	44	37 (1)	168 (27)	70

*Level 1: nations; Level 2: states, regions and cities; Level 3: counties, tracts and parishes
Ref: Wilkinson and Pickett (2006).

The aggregation bias might be generated if one uses aggregate data to investigate the individual health income relationship. Gravelle et al. (2002) say that 'there are serious conceptual difficulties in using aggregate cross-sections as a means of testing hypotheses about the effect of income, and its distribution, on the health of individuals' (p. 577).

Consider the individual model:

$$(2.1)\quad m_{ik} = \beta_0 + \beta_1 y_{ik} + \beta_2 y_{ik}^2 + \beta_3 R_{ik} + \beta_4 z_{ik} + e_{ik}$$

where m_{ik} is the mortality risk of individual i in country k, y_{ik} is his/her income, and e_{ik} is an error term. R_{ik} is a variable reflecting the relative income hypothesis that an individual's health depends on the income of others as well as his own income. z_{ik} is a vector of non-income variables affecting health.

Average Eq. (2.1) by the population in county k denoted by N_k and Eq. (2.2) is obtained:

$$(2.2) \quad m_k = \beta_0 + \beta_1 y_k + \beta_2 s_k + \beta_3 R_k + \beta_4 z_k + e_k$$

where $m_k = \sum_i m_{ik} \Big/ N_k$ is population mortality in country k, $y_k = \sum_i y_{ik} \Big/ N_k$ is average income, $s_k = \sum_i y^2{}_{ik} \Big/ N_k$ is the mean of square average income. Likewise, $R_k = \sum_i R_{ik} \Big/ N_k$, $z_k = \sum_i z_{ik} \Big/ N_k$ and $e_k = \sum_i e_{ik} \Big/ N_k$.

However, an aggregate model typically looks like Eq. (2.3):

$$(2.3) \quad m_k = b_0 + b_1 y_k + b_2 y_k^2 + b_3 G_k + \xi_k$$

In Eq. (2.3) m_k is population mortality rate, y_k is per capita income, y_k^2 is the square of average income and G_k is the measure of income inequality in country k. Since, the coefficients in Eq. (2.2) are of interest instead of these in Eq. (2.3); the question is whether we can recover the parameter of Eq. (2.2) from Eq. (2.3).

To recover the parameters for Eq. (2.2) from a specification such as Eq. (2.3): let α_{jo} denote the coefficient obtained from regressing the variable o on the variable j. Gravelle et al. regress s_k, R_k, and z_k on the explanatory variables in Eq. (2.3), respectively.

$$(2.4) \quad s_k = \delta_0 + \alpha_{ys} y_k + \alpha_{y^2 s} y_k^2 + \alpha_{Gs} G_k + \mu_k$$

$$(2.5) \quad R_k = \alpha_0 + \alpha_{yR} y_k + \alpha_{y^2 R} y_k^2 + \alpha_{GR} G_k + \varphi_k$$

$$(2.6) \quad z_k = \gamma_0 + \alpha_{yz} y_k + \alpha_{y^2 z} y_k^2 + \alpha_{Gz} G_k + \tau_k$$

Substitute Eq. (2.4), (2.5), and (2.6) for s_k, R_k, and z_k respectively, and the Eq. (2.7) is obtained.

$$(2.7)\quad m_k = (\beta_0 + \beta_2\delta_0 + \beta_3\alpha_0 + \beta_4\gamma_0) + \left(\beta_1 + \beta_2\alpha_{ys} + \beta_3\alpha_{yR} + \beta_4\alpha_{yz}\right)y_k$$

$$+\left(\beta_2\alpha_{y^2s} + \beta_3\alpha_{y^2R} + \beta_4\alpha_{y^2z}\right)y_k^2 + (\beta_2\alpha_{Gs} + \beta_3\alpha_{GR} + \beta_4\alpha_{Gz})G_k$$

$$+(\beta_3\varphi_k + \beta_4\tau_k + \beta_2\mu_k + e_k)$$

Rearranging Eq. (2.7), we obtain Eq (2.8).

$$(2.8)\quad b_1 = \beta_1 + \beta_2\alpha_{ys} + \beta_3\alpha_{yR} + \beta_4\alpha_{yz}$$

$$b_2 = \beta_2\alpha_{y^2s} + \beta_3\alpha_{y^2R} + \beta_4\alpha_{y^2z}$$

$$b_3 = \beta_2\alpha_{Gs} + \beta_3\alpha_{GR} + \beta_4\alpha_{Gz}$$

Assume R_k and G_k are the same variables (α_{GR}=1) and ignore the variable z_k to simplify the processor of analysis. The Eq. (2.8) becomes Eq. (2.9).

$$(2.9)\quad b_1 = \beta_1 + \beta_2\alpha_{ys} + \beta_3\alpha_{yR}$$

$$b_2 = \beta_2\alpha_{y^2s} + \beta_3\alpha_{y^2R}$$

$$b_3 = \beta_2\alpha_{Gs} + \beta_3$$

The b_1 and b_3 will be unbiased only under some conditions. For example, b_1 will be equal to β_1 when β_2=0 or α_{ys}=0 and one of both coefficients, β_3=0 or α_{yR}=0. According to the previous studies, it is a little implausible that α_{ys} and α_{yR} are equal to 0. It should be a positive association. Thus, the b_1 will be unbiased only when the individual mortality risk-income relationship is linear and when the relative income hypothesis does not hold.

The coefficient of interest, b_3, will be unbiased when either β_2 or α_{GS} is equal to 0. It is a little implausible that there is no association between the indicators of the income inequality index and the average of square income. This relationship is positive theoretically. Hence, b_3 is only unbiased when the association between income and individual mortality risk is linear. When the individual mortality risk-income association is nonlinear ($\beta_2 \neq 0$), the estimated coefficient of income inequality is not identical to the coefficient of relative income on individual mortality risk, even if the inequality index is perfectly identical to the index of relative income (α_{GR} =1).

Putting these restrictions together, it is unlikely that an equation like (2.2) be recovered from (2.3). Gravelle et al. (2002) suggest that disentangling the individual health income relationship is the first step to test the relative income hypothesis. If this relationship is nonlinear, attempts to test the relative income hypothesis with aggregate level data are unlikely to be fruitful. Meanwhile, the estimates of the effect of absolute income on health are also likely biased. The individual health income relationship may contaminate the results of testing the income inequality hypothesis with aggregate data if it is nonlinear. They also say ‘Even in the absence of confounding by omitted health affecting variables, and with much more accurate data than are currently available, aggregate level studies are incapable of distinguishing between the direct effect of income inequality on individual health and the artificial effects of nonlinearity in the individual health income relationship.’

2.4 Conclusion

Compared to the absolute income hypothesis, the relative income and income inequality hypotheses have attracted more attention recently. The key point of the relative income hypothesis and the income inequality hypothesis is economic transition. People emphasize their relative income rather than the absolute income when the country becomes affluent. Social comparison provides a theoretical explanation for the relative income hypothesis and income inequality hypothesis. However, Wilkinson and Pickett (2006) show that the papers using small area data or individual level data do not tend to support the income inequality hypothesis. This conclusion is consistent with the argument of aggregate bias (Gravelle et al., 2002).

Two questions therefore motivate the rest of this thesis. First, is the evidence in Taiwanese case supporting the income inequality hypothesis a truth or an artefact and are the absolute income hypothesis and the income inequality hypothesis coexistent or exclusionary? Secondly, does the absolute income still significantly affect health status even if Taiwan has passed the stage of economic transition? Chapter 3 combining the mortality data and family income and expenditure survey data avoids the aggregation bias to test the absolute income hypothesis and the income inequality hypothesis under the assumption of health social gradient. Chapter 4 and Chapter 5 use another data set whose sample is elder citizens to investigate the relationship between income and self- assessed health, the measurement of depression, and life satisfaction. Chapter 4 reveals at once the individual’s health income risky relationship and the income related health inequality. Chapter 5 attempts to provide a robust result for the test of absolute income hypothesis by using the strategies of identification.

Chapter 3. Socioeconomic determinants of mortality in Taiwan: Combining individual data and aggregate data[6]

3.1 Introduction

With the increase of health expenditure in many countries, there has been an increase in health related research. Prevention and treatment are the two substantial approaches in this area. The investigation of a relationship between health and income is one part of the former topic because it proposes methods of prevention through social phenomena. There is no doubt that mental health affects physical health. Many factors might have impacts on mental health and further affect physical health through several mediators. Stress is a mediator discussed in a vast literature. On the other hand, there are also factors that affect physical health directly. In other words, socio-economic factors might affect physical health by direct and indirect pathways.

A lot of literature has been devoted to the investigation of social phenomena affecting health status. According to Wilkinson (1996), the phenomena can be summarized as follows: 1. Financial insecurity; 2. Unemployment; 3. Social contact; 4. Social mobility; 5. Occupational class; 6. Consumer culture; 7. Other factors. The aforementioned phenomena are potential determinants of health. These determinants affect health status through stress or other psychological responses. However, those determinants are also relevant to socioeconomic status. Thus, appropriate policies can not only improve these phenomena to accumulate social capital but also promote the health status of the whole society while reducing somewhat health expenditure in the future.

[6] This chapter is collaborated with Dr. Leon-Gonzalez and has been published on *Health Policy* 99 (2011) 23-36.

Many empirical studies have investigated the relationship between income and health and two important hypotheses are the absolute income hypothesis and the income inequality hypothesis (for excellent reviews of this wide literature see chapter 2).

Numerous studies using aggregate data have found support for the income inequality hypothesis (see Table 2-1). However, they have been criticized by some authors who argued that only individual level data can be used to discriminate between the competing hypotheses (e.g. Gravelle, 1998; Wagstaff and Doorslaer, 2000; Gravelle et al., 2002; Wildman et al., 2003; Jen et al., 2008). On the other hand, studies that analyze individual-level data often use self-reported measures of health, which are more prone to measurement error than mortality data. There are studies that analysed individual data on income and mortality (e.g. Fiscella and Franks, 1997; Daly et al., 1998; Fiscella and Franks, 2000; Lochner et al., 2001; Fritjers, Haisken-DeNew and Shields, 2005). However, individual data on mortality is not available in many countries. Furthermore, since mortality is a low probability event at the individual level, individual data on mortality provides a limited amount of information, due to the small number of people who die in each wave of the dataset.

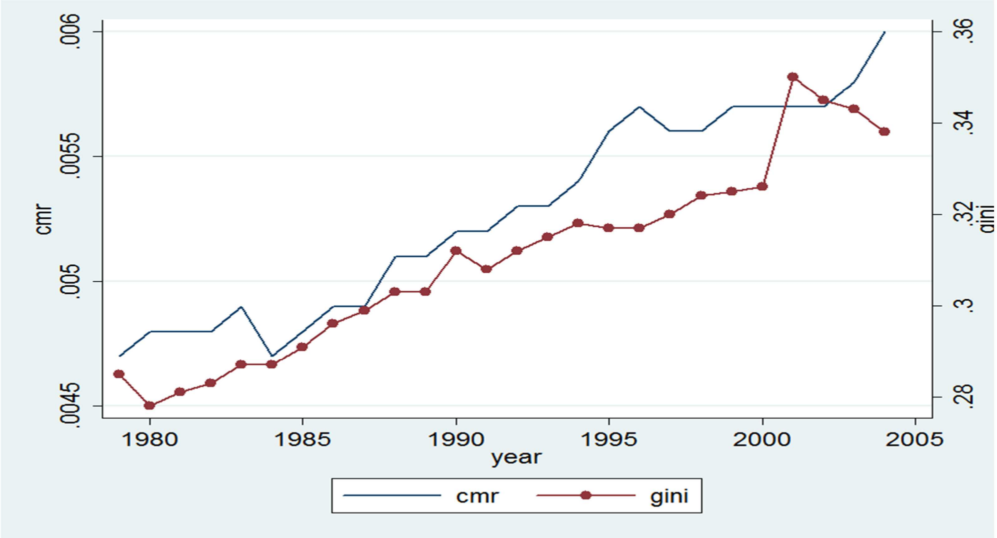
In this chapter aggregate mortality data is used, but following a recent strand of epidemiological literature (Prentice and Sheppard, 1995; Salway and Wakefield, 2005), individual level data on income and other socio-economic characteristics are also used to ameliorate aggregation bias. The econometric approach is similar also to the econometric methods proposed for repeated cross-sections by Deaton (1985) and Browning, Deaton and Irish (1985) (see Cameron and Trivedi, 2005 (p.p. 770-773) for a summary of the econometric methods and Salway and Wakefield (2001) for a review of the related epidemiological literature). The approach consists on first defining a model at the individual level, and then estimating the econometric model that results from aggregating the individual level model over individuals in a county. This approach is made feasible by using individual level data to estimate county averages of regressors.

This chapter is organised as follows. Section 2 introduces the characteristics of income inequality and mortality in Taiwan. Section 3 briefly discusses the concept of aggregation bias. Section 4 explains the econometric approach followed in this paper to avoid the aggregation bias and explains the limitations of our econometric approach with respect to using individual-level data for both the dependent and the independent variables. Section 5 describes the data and section 6 presents the results. Section 7 concludes.

3.2 Income distribution and mortality in Taiwan

Taiwan's income distribution attracts many researchers' attention because the rapid development and limited changes in the income distribution in the past decades. After Taiwan government implemented an array of reforms such as land reform and a vigorous industrialization process, the society had drastic evolution. The agricultural share of labour force went down from slightly less than 30 percent in 1979 to 10 percent in 1995. The labour force in service sector replaced that in the industrial sector gradually and now it is almost half of labour force. Due to the change of social structure, the labour force participation increased significantly. Meanwhile, the other changes, for example, the fall of family size and increase of schooling level of population also contributed to the rapid development. However, the income inequality did not expand with the development. This process of development is different from the process of most western countries, especially the US and the UK. Table 3-1 shows the comparison of Gini coefficient in the selected countries.

Figure 3.1 Crude Mortality Rate and Gini Coefficient



A large literature has investigated Taiwan's income inequality. These studies[7] investigate the causes of income inequality from different points of view. For brevity these studies are not summarized in detail here.

According to the life statistics from the Department of Health, at the beginning of 20th century Taiwan's crude mortality rate was 33.7‰. In the middle century, it dropped down to 11.5‰ and it became less than 10‰ after 1951. After 1963, the crude mortality in Taiwan was maintained at approximately 5‰. Figure 3.1 shows the crude mortality and Gini coefficient data. The trends of Gini coefficient and mortality are both going up over time. Mortality has changed from 4.7‰ to 6‰ (in the period 1979 - 2005), whereas the Gini coefficient has gone from 0.278 to 0.345 (in the same period).

[7] Fei et al (1979), Kuo et al. (1983), Jiang (1992), Gindling et al. (1995), Fields and O'Hara (1996), Hung (1996), Chu (1997), Fields and Leary (1997), Fournier (1997), and Bourguignon et al (1998a, 1998b), etc.

Table 3-1 Income Distribution in selected countries

Country	Year	Percentage share of household income, by percentile groups of households (%)		Ratio of income share of highest 20% and lowest 20% households	Gini coefficient
		Lowest 20%	Highest 20%		
1.Low-income countries					
Vietnam	2002**	7.5	45.4	6.05	0.370
India	1999**	8.9	43.3	4.87	0.325
Indonesia	2002**	8.4	43.3	5.15	0.343
2. Mid-income countries					
China	2001**	4.7	50.0	10.64	0.447
Philippines	2000**	5.4	52.3	9.69	0.461
Bulgaria	2001*	6.7	38.9	5.77	0.319
Thailand	2000**	6.1	50.0	8.20	.0432
Colombia	1999*	2.7	61.8	22.89	0.576
Romania	2002**	7.9	41.0	5.19	0.303
Brazil	2001*	2.4	63.2	26.33	0.593
Russian Federation	2002**	8.2	39.3	4.79	0.310
Malaysia	1997*	4.4	54.3	12.43	0.492
Mexico	2000*	3.1	59.1	19.06	0.546
3.High-income countries					
Taiwan	1980	8.8	36.8	4.17	0.277
	1994	7.3	39.2	5.38	0.318
	2004	6.7	40.2	6.03	0.338
Korea, Rep	2000	6.2	42.6	6.84	0.352
New Zealand	1997*	6.4	43.8	6.84	0.362
Italy	2000*	6.5	42.0	6.46	0.360
Singapore	2000	2.4	51.0	20.91	0.481
Canada	1998*	7.0	40.4	5.77	0.331
Germany	2000*	8.5	36.9	4.34	0.283
Finland	2000*	9.6	36.7	3.82	0.269
Hong Kong	2001	3.2	56.5	17.66	0.525
Sweden	2000*	9.1	36.6	4.02	0.250
United Kingdom	1999*	6.1	44.0	7.21	0.360
Japan	1999	8.0	38.9	4.84	0.301
U.S.A.	2003	4.5	44.4	9.83	0.394
Norway	2000*	9.6	37.2	3.88	0.258
Luxembourg	2000*	8.4	38.9	4.63	0.308

Note: 1. * refers to income shares by percentiles of population and ranked by per capita income. ** refers to consumption share by percentiles of population and ranked by per capita consumption. 2. Source: World Development Report, 2005 (the World Bank). Korea, Rep.: Social statistics Survey, 2000. Japan: National Survey of Family Income and Expenditure, 1999. U.S.A Alternative Income Estimates in the United States, 2003. Hong Kong: Population Census Main Report, 2001.Singapore: Singapore Census of Population, 2000.
Source: the Report of FIES, 2004

3.3 Discussion of bias

To discuss further the concept of aggregation bias mentioned in Chapter 2, consider the following individual level model for the relationship between a measure of health (h_{itk}) and some regressors X_{itk}:

$$(3.1) \quad h_{itk} = f(\alpha_k + \beta X_{itk}, \varepsilon_{itk})$$

where i refers to the individual, t refers to time, k refers to county, ε_{itk} is an unobserved error term and f(.) is a known function. Suppose a researcher does not have observations on individual data for h_{itk} and X_{itk}, but observes instead the county level variables X_{tk} and h_{tk}:

$$X_{tk} = \frac{\sum_{i=1}^{N_k} X_{itk}}{N_{tk}} \quad h_{tk} = \frac{\sum_{i=1}^{N_k} h_{itk}}{N_{tk}}$$

where N_{tk} is the population size in the k_{th} county in period t. The aggregation bias is likely to arise if the researcher attempts to estimate the following aggregate level model:

$$(3.2) \quad h_{tk} = f(\alpha_k^* + \beta^* X_{tk}, \varepsilon_{tk})$$

Note that the true relationship between X_{tk} and h_{tk}, implied by Eq. (3.1), is:

$$(3.3) \quad \frac{\sum_{i=1}^{N_k} h_{itk}}{N_{tk}} = \frac{\sum_{i=1}^{N_k} f(\alpha_k + \beta X_{itk}, \varepsilon_{itk})}{N_{tk}}$$

In general, Eq. (3.2) and Eq. (3.3) are very different. Hence, estimation of Eq. (3.2) will give biased estimates of α_k and β. However, if f was a linear function, then Eq. (3.2) and Eq. (3.3) would be identical, and hence the aggregation bias would not arise.

Gravelle (1998) and Gravelle, Wildman and Sutton (2002) note a typical example in which aggregation bias does arise. Assume that the individual level model is given by:

$$(3.4) \quad h_{itk} = \alpha_k + \beta_1 I_{itk} + \beta_2 I_{itk}^2 + \varepsilon_{itk}$$

where I represents income and I^2 is square income. Some cross-country studies might use GDP per capita as a measure of average income, but would not have a measure of the average value of I^2_{itk}. Hence, if Eq. (3.4) defines the true relationship between health and income, a regression of mortality on GDP per capita and GDP per capita squared would suffer from the problem of omitted variable bias (Maddala, 2001(p.p. 159-163)), because GDP per capita squared is often not a good approximation of $\sum_{i=1}^{N_{tk}} I_{itk}^2 / N_{tk}$.

3.4 Econometric Approach

3.4.1 Model

The individual-level model is as follows:

$Y_{itk} = 1$ the individual dies with probability P_{itk}

$Y_{itk} = 0$ the individual survives with probability $1 - P_{itk}$

where

$$(3.5) \quad P_{itk} = \beta X_{itk} + \alpha_k$$

i, *t*, *k* denote the i^{th} individual, t^{th} year, and k^{th} county, respectively, and X_{itk} is a vector of regressors. The constant α_k captures the effect of time-invariant county specific characteristics that affect the probability of dying. To simplify the process of estimation, it is assumed that the probability of dying depends linearly on the regressors[8], but note that the regressors might include powers of income, age and other variables. Hence, this approach does not rule out the possibility that health and income might be related non-linearly, as argued by previous studies (e.g. Gravelle, 1998; Gravelle et al., 2002).

The expected value of Y_{itk}, expressed as E(Y_{itk}), is equal to 1*Pr(Y_{itk}=1)+0*Pr(Y_{itk}=0)= Pr(Y_{itk}=1). Therefore, the model can be defined as

$$(3.6) \quad Y_{itk} = \beta X_{itk} + \alpha_k + \varepsilon_{itk}$$

where ε_{itk} is an error with zero mean. Furthermore, the average value of Y_{itk} in county k in year t is

$$Y_{tk} = \frac{1}{N_{tk}} \sum_{i=1}^{N_{tk}} (Y_{itk})$$

where N_{tk} is the population size in the k_{th} county and t^{th} period. Note that Y_{tk} is the mortality rate in county k in period t. Hence, Eq. (3.6) implies that Y_{itk} can be expressed as:

$$(3.7) \quad Y_{tk} = \beta X_{tk} + \alpha_k + \varepsilon_{tk}$$

where X_{tk} is a vector containing the average values of the regressors in X_{itk}:

$$X_{tk} = \frac{1}{N_{tk}} \sum_{i=1}^{N_{tk}} (X_{itk})$$

and:

[8] Non-linear links between the probability and the set of regressors could also be considered following the approach in Prentice and Sheppard (1995).

$$\varepsilon_{tk} = \frac{\sum_{i=1}^{N_{tk}} \varepsilon_{itk}}{N_{tk}}$$

In this study, the data on Y_{tk} (mortality data) are available and the sample averages of X_{itk}, $\hat{X}_{tk} = \frac{1}{\tilde{N}_{tk}} \sum_{i=1}^{\tilde{N}_{tk}} (X_{itk})$, with $\tilde{N}_{tk} < N_{tk}$, are used to proxy for X_{tk}. Given the large sample size used to calculate these averages (see Table 3-2), the bias introduced because of measurement error is negligible (Prentice and Sheppard, 1995; Salway and Wakefield, 2008). Prentice and Sheppard (1995) by means of a Monte Carlo experiment found that when $\tilde{N}_{tk} = 100$, the bias was about -2.0%, with a 95% confidence interval of (-3.8%, -0.1%). Moreover, they found that the correction they proposed in order to reduce the measurement bias, which is superior asymptotically, in practice was not effective when $\tilde{N}_{tk}$ was at least 100. The Monte Carlo experiment carried out by Salway and Wakefield confirms that the measurement error bias would be negligible in our case. They found that even when $\tilde{N}_{tk}$ is as small as 25, the bias is only about 6%.

Note that the main difference in practice of our approach with other aggregate data studies is that the latter implicitly assume that $E(X^2)$ can be approximated with $(E(X))^2$, where X denotes an explanatory variable, and $E(.)$ is the expected value operator. However, this assumption is not necessary here, while the aggregate level model Eq. (3.7) is still consistent with the individual level model Eq. (3.5), which allows for non-linear links between health and other variables.

With respect to identification of the parameters, note that in our case the vector of regressors X_{itk} will contain a measure of income (e.g. $\ln(I_{itk})$), squared income (e.g. $[\ln(I_{itk})]^2$) and a measure of inequality (e.g. G_{tk}). Hence in the aggregate level model

(3.7) X_{tk} will contain $E(\ln(I_{itk})), E([\ln(I_{itk})]^2)$ and G_{tk} . Given that $E([\ln(I_{itk})]^2) = \text{var}(\ln(I_{itk})) + [E(\ln(I_{itk}))]^2$ is expressed, the aggregate level model (3.7) can be written as:

$$
\begin{aligned}
&Y_{tk} = \beta_I E(\ln(I_{itk})) + \beta_{I2} E([\ln(I_{itk})]^2) + \beta_G G_{tk} + \tilde{\beta}\tilde{X}_{tk} + \alpha_k + \varepsilon_{tk} = \\
&\beta_I E(\ln(I_{itk})) + \beta_{I2}[E(\ln(I_{itk}))]^2 + \beta_{I2}\,\text{var}(\ln(I_{itk})) + \beta_G G_{tk} + \tilde{\beta}\tilde{X}_{tk} + \alpha_k + \varepsilon_{tk}
\end{aligned}
$$

From this expression it is clear that the parameters are identified even if one chooses $\text{var}(\ln(I_{itk}))$ as a measure of inequality (i.e. $G_{tk} = \text{var}(\ln(I_{itk}))$, but in such a case high correlation between the regressors might be encountered, and hence tests of individual significance might have low power. In this chapter G_{tk} is a Gini coefficient, whose correlation with $E([\ln(I_{itk})]^2)$ is only 0.12. One could also use other measures of inequality such as the 90/10 ratio, which is likely to have smaller correlation with $E([\ln(I_{itk})]^2)$ and $E[\ln(I_{itk})]$.

Fixed effects and random effects models are used to estimate the parameters and the results are compared. However, it is possible that the error term ε_{tk} has heteroskedasticity and/or autocorrelation. Hence, robust fixed effects estimation is used to correct this bias. As for random effects models, the robust population averaged estimation is used to account for heteroskedasticity and autocorrelation.

Table 3-2 Number of values to calculate county averages of regressors: Minimum value, 5% percentile, Mean, 95% percentile and Maximum value.

Year	Minimum	5%	Mean	95%	Maximum
1	291	896	2357	5637	6755
2	286	850	2342	5211	6740
3	453	1110	3344	8155	9590
4	457	1077	3269	8474	9555
5	458	1089	3392	9165	10037
6	449	1113	3490	9902	9957
7	444	981	3249	10050	10465
8	449	989	3364	10976	10989
9	407	969	3349	11011	11042
10	400	895	3283	10795	11143
11	359	941	3236	10695	11139
12	381	871	3155	8778	10718
13	331	840	3061	8576	10091
14	338	828	3038	8420	10155
15	294	752	2993	8509	9853
16	289	830	2975	8358	10001
17	288	760	2930	8386	9845
18	235	728	2922	8438	9959
19	258	682	2868	8153	9929
20	399	788	2508	7459	9332
21	425	711	2328	6891	9470
22	374	817	2282	5771	9468
23	371	843	2287	5782	9036
24	379	873	2170	5582	8981
25	367	815	2164	5278	9145
26	353	805	2104	5477	7169
27	595	839	2152	5504	6889
28	617	743	2085	5302	6744
29	628	800	2061	5323	6437

3.4.2 Scope and Limitations

The aggregate approach proposed in Prentice and Sheppard (1995) produces consistent estimates of the parameters of the individual-level model under a set of assumptions which is more restrictive than would be necessary if individual-level data were available. The crucial extra assumption is that the error term in the individual-level model is uncorrelated with the regressors. This assumption could be relaxed to some extent by using fixed effects and individual-level data. That is, individual-level data are able to effectively control for all individual characteristics that are time-invariant, even for those that are not observed. In the aggregate approach described here, however, only the observed individual characteristics (e.g. income, age, education, occupation, gender, etcetera) can be controlled.

Another assumption is that $\hat{X}_{tk}$ is a consistent estimator of X_{tk} and that $\tilde{N}_{tk}$ is sufficiently large. This requires that the sample used to calculate $\hat{X}_{tk}$ is representative of the population in that county and year. Since this sample is taken at a particular date within the year, it is necessary to assume that $\hat{X}_{tk}$ is roughly constant during the year. Note that in this chapter income adjusted by the number of household members is used as one of the regressors. Thus, if X_{tk} represents the yearly average, it is implicitly assumed that the probabilities of death and birth do not vary over the year as much as to make the estimator $\hat{X}_{tk}$ inconsistent.

3.5 Data

This chapter combines the crude mortality rate of district obtained from Life Statistic of Department of Health of Taiwan and the individual socioeconomic data obtained from Family Income and Expenditure Survey to create a panel data set at district level. The definition of crude mortality rate is the proportion of total deaths per 1000 people in a year. It is accurate statistic data reported by hospitals. Family Income and Expenditure Survey is a large survey which has been conducted every year since 1974. The purpose of Family Income and Expenditure Survey is to analyse family's income and consumption structure. It comprises detailed information: 1. the socioeconomic status of the head of household; 2. the socioeconomic status of income earners; 3. income pattern; 4. distributions of disposable income, final consumption, expenditure, and saving; 5. the changes in financial assets and liabilities; 6. fixed capital consumption and gross capital formations of family and small scale unincorporated enterprise operated by family.

The number of household samples drawn from each district was proportional to its population size. The number of households in the survey varies from year to year. The smallest total sample size, in terms of households, is 9033 in 1977 and the largest one is 16435 in every year from 1983 to 1994. The Family Income Expenditure Survey contains data on the members of each household. The smallest total sample size, in terms of number of individuals, is 47411 in 2004 and the largest one is 77393 in 1983.

Total districts in Taiwan now are twenty three. These twenty-three districts include sixteen counties, five cities, and two municipalities governed directly under the jurisdiction of the Central Government (Taipei city and Kaohsiung city). However, the created panel data set is unbalanced because there were only twenty-one counties before 1982.[9]

The created panel data set comprises 29 years from 1976 to 2004 and 23 counties. The total observations are 655 (23 districts multiplied by 29 years but subtracting 12 observations which are missing because two districts have no data from 1976 to 1981). The dependent variable is the number of deaths per 1000 people so that it ranges between 0 and 1000 instead of between 0 and 1. The econometric approach here does not take explicitly into account that the dependent variable is bounded. However, it is not a problem because none of fitted values violated this restriction (the fitted values for the regression shown in Table 3-6 varied between 4.48 and 7.92, with mean 5.827). Two explanatory variables, the mean of log of disposable income and the long-run mean of log

[9] These two extra districts are Hsinchu city and Chiayi city, which were two towns that belonged to Hsinchu county and Chiayi county originally. Because the population in these two cities grew, they were upgraded to the same level as county. Roughly, Hsinchu county and Chiayi county maintain the same scale of territory.

disposable income, are concerned in testing the absolute income hypothesis and Gini coefficient is used to test the income inequality hypothesis[10]. If the mean of log of disposable income or the long-run mean of log disposable income has a negative and significant effect on crude mortality rate, the absolute income hypothesis will be supported. Similarly, the income inequality hypothesis will be supported if Gini coefficient has a positive and significant effect on crude mortality rate. The three concerned explanatory variables in the panel data set are produced from individual data. Income refers to disposable household income at individual level divided by two income equivalent scales. One is the number of members in the household, named income equivalent scale 1, and the other one is as the formula: $(adult + 0.5 \times children)^{0.9}$, named income equivalent scale 2.

The other explanatory variables in the created panel data set are: age, age squared, gender, 5 variables of educational achievement, and 7 variables for occupation. Those variables are the districts' means which are computed from individual data. Therefore, the dummy variables of gender, education achievement, and occupation in individual data transform into the numerical variables in the created panel data set.

In the individual data, education is categorized into 5 groups according to the number of years enrolled at school and occupation into 7 groups according to the type of job. The five groups in education are less than 1 (illiteracy), 1-6 (primary school), 7-9 (junior high school), 10-12 (senior high school), and more than 12 (university and postgraduate). Note that these variables enter the individual level Eq. (3.5) as dummy variables, which imply that they enter Eq. (3.7) as proportions. Because the sum of these proportions equals one, only four of them are included in the model. With respect to

[10] Gini coefficient at county level is not available in Family Income and Expenditure Survey. It is computed in stata according to the formula of Gini coefficient.

occupation, the seven groups are: 1. Professionals, 2. Clerks, 3. Technicians and associate professionals, 4. Service workers, shop and market sales workers, 5. Agricultural, animal, husbandry, forestry, and fishing workers, 6. Product machine operators and related workers, 7. Unemployed.

These occupation variables are denoted from occu1 to occu7. Of course, the sum of these seven variables equals to one too, so only 6 of them enter the regression. The definition of household disposable income is total receipts minus non-consumption expenditure. [11] Further, the household disposable income is divided by two aforementioned income scales to obtain the individual disposable income. We then calculate the average of individual disposable income and individual disposable income squared as explained near to Eq. (3.7).

Table 3-3 is a statistical description of created panel data set. The definition of variables is displayed in Table A-1. The average mortality rate at county level is 0.58%. The average log income of all counties across 29 years is between 11.46 and 11.74 which approximate to NT$94,700 and NT$125,300 respectively. The Gini coefficient is between 0.258 and 0.282. The average log income of county divided by equivalence scale 2 is bigger than by equivalence scale 1 whereas Gini coefficient calculated by scale 2 is smaller than by scale 1. This is different from the argument of some literature that average income has a positive relationship with Gini coefficient. The reason causing this circumstance is the weight of children in the equivalence scale. In scale 1 the weight of children is 1 which is the same as that of adults whereas it is 0.5 in scale 2. Meanwhile, this circumstance reflects that high income households might have fewer children than low income households.

[11] Total receipts include six terms. They are compensation of employees, entrepreneurial income, property income, imputed rent income, current transfer receipts, and miscellaneous receipts. The non-consumption is composed of interest and current transfer expenditures.

Table 3-3 Summary Statistics (N=23, T=29)

Variable	Mean	Std. Dev.	Min.	Max.
Deaths per 1000 people	5.827	1.39	1.88	10.2
Mean of log disposable income 1†	11.457	0.745	9.672	12.755
Mean of square log disposable income 1†	132.093	16.797	93.855	162.932
Gini coefficient 1†	0.282	0.026	0.218	0.388
Mean of log disposable income 2††	11.74	0.702	10.021	12.948
Mean of square log disposable income 2††	138.577	16.232	100.65	167.879
Gini coefficient 2††	0.258	0.028	0.189	0.375
Age	30.894	4.211	21.065	41.513
Gender	0.505	0.01	0.46	0.562
Edu 1(less than 1 year)	0.186	0.044	0.081	0.303
Edu 2(1 - 6 years)	0.346	0.068	0.189	0.533
Edu 3(7 – 9 years)	0.166	0.018	0.117	0.25
Edu 4(10 – 12 years)	0.197	0.051	0.065	0.299
Edu 5(More than 12 years)	0.104	0.063	0.018	0.366
Occu1	0.026	0.011	0.005	0.071
Occu2	0.031	0.029	0	0.14
Occu3	0.049	0.02	0.011	0.128
Occu4	0.079	0.019	0.036	0.148
Occu5	0.09	0.076	0.0002	0.304
Occu6	0.146	0.04	0.024	0.244
Occu7	0.58	0.042	0.46	0.719
Long-run mean of Gini coefficient 1†	0.282	0.015	0.263	0.3
Long-run mean of Gini coefficient 2††	0.258	0.017	0.236	0.32
Long-run mean of log disposable income 1†	11.457	0.174	11.251	11.856
Long-run mean of log disposable income 2††	11.74	0.172	11.525	12.129

† Variables are generated by income equivalent scale 1

†† Variables are generated by income equivalent scale 2.

Table 3-4 shows the average Gini coefficient in each district over 29 years. The variation in each district over 29 years is small. The range of standard deviation is between 0.012 and 0.035. Kaohsiung city and Taipei city which are the only two municipalities directly under the jurisdiction of the Central Government have the smallest and the largest fluctuation of Gini coefficient. Table 3-5 shows the county Gini coefficient and country Gini coefficient in each year.

One thing worth to mention is the correlation between the average income and Gini coefficient. If both variables have a high correlation, the tests of the absolute income effect and the income inequality effect would have low power. It may not be possible to disentangle the two income hypotheses separately. However, this problem does not arise here because the correlation coefficients are 0.1 and 0.2 for the two alternative equivalence scales use in this chapter.

Table 3-4 The mean of Gini coefficient in each district

District	Mean [Std. Dev.]	District	Mean [Std. Dev.]
Taipei County	0.275 [0.017]	Pingtung County	0.274 [0.02]
Yilan County	0.278 [0.024]	Taitung County	0.306 [0.033]
Taoyuan County	0.267 [0.013]	Hualien County	0.317 [0.022]
Hsinchu County	0.265 [0.015]	Penghu County	0.304 [0.032]
Miaoli County	0.267 [0.05]	Keelung City	0.271 [0.022]
Taichung County	0.269 [0.02]	Taichung City	0.287 [0.021]
Changhua County	0.28 [0.014]	Tainan City	0.277 [0.015]
Natou County	0.298 [0.019]	Kaohsiung City	0.278 [0.012]
Yunlin County	0.276 [0.024]	Taipei City	0.294 [0.035]
Chiayi County	0.289 [0.017]	Hsinchu City	0.321 [0.027]
Tainan County	0.28 [0.02]	Chiayi City	0.307 [0.02]
Kaohsiung County	0.273 [0.014]		

Table 3-5 The county Gini coefficient and Country Gini coefficient in each year[12]

Gini \ Year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Max	0.335	0.337	0.334	0.312	0.323	0.356	0.342	0.341	0.347	0.355
Min	0.237	0.219	0.252	0.25	0.233	0.238	0.235	0.254	0.245	0.254
Mean	0.264	0.27	0.283	0.281	0.272	0.276	0.284	0.28	0.287	0.292
(S.D)	(0.025)	(0.026)	(0.022)	(0.019)	(0.019)	(0.023)	(0.024)	(0.021)	(0.023)	(0.025)
County sample	21	21	21	21	21	21	23	23	23	23
Country Gini	0.28	0.284	0.287	0.285	0.278	0.281	0.283	0.287	0.287	0.291

Gini \ Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Max	0.373	0.345	0.351	0.345	0.363	0.342	0.329	0.338	0.355	0.324
Min	0.246	0.247	0.253	0.251	0.25	0.257	0.257	0.261	0.259	0.242
Mean	0.292	0.287	0.291	0.294	0.29	0.291	0.292	0.298	0.29	0.278
(S.D)	(0.033)	(0.022)	(0.027)	(0.026)	(0.03)	(0.024)	(0.022)	(0.022)	(0.023)	(0.024)
County sample	23	23	23	23	23	23	23	23	23	23
Country Gini	0.296	0.299	0.303	0.303	0.312	0.308	0.312	0.315	0.318	0.317

Gini \ Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Max	0.331	0.33	0.322	0.344	0.352	0.35	0.367	0.376	0.375
Min	0.248	0.246	0.231	0.233	0.241	0.261	0.259	0.239	0.242
Mean	0.279	0.277	0.277	0.277	0.28	0.297	0.294	0.289	0.283
(S.D)	(0.024)	(0.021)	(0.023)	(0.028)	(0.032)	(0.026)	(0.028)	(0.033)	(0.033)
County sample	23	23	23	23	23	23	23	23	23
Country Gini	0.317	0.32	0.324	0.325	0.326	0.35	0.345	0.343	0.338

[12] The county Gini coefficient is computed using the individual disposable income whereas the country Gini coefficient is computed using the household disposable income.

3.6 Results

3.6.1 Fixed effects and random effects

Robust fixed effect estimation (Wooldridge, 2002 (Section 10.5.4)) allows for heteroskedasticity and (intra-group) autocorrelation in the error term[13]. Meanwhile, a random-effects type estimation, using a robust population averaged method (Wooldridge, 2002 (Section 10.4.2)) which assumes, unlike the fixed effects, that the time-invariant unobserved variables are uncorrelated with the explanatory variables is also presented. The robust fixed effects estimation allows for heteroskedasticity and autocorrelation in the error term. Results are shown in Table 3-6. The results with random and fixed effects are similar except for the occupational variable. This similarity implies that time-invariant omitted determinants of health, which are captured in the individual effect, are not much correlated with the included regressors.

None of the income variables are individually significant. The joint F-test of mean of log disposable income and its square term is also insignificant at the 5% level. Neither is the F-test significant which is implemented on the three income variables: mean of log disposable income, its square term, and Gini coefficient. Thus, no evidence is found for either the absolute or income inequality hypotheses. However, an education variable (Edu5) is significant at a 5% level. This is individuals with more than 12 years of education have a lower probability of dying (holding other things constant).

[13] The residuals from the regressions in Table 3-7 do indeed show positive and significant autocorrelation. A negative correlation coefficient might be indicative of selective mortality. This implies that after negative shock to the health of a county (i.e. a strong flu epidemic) only the stronger individuals remain. If so, the mortality rate in the following period will be smaller, because the remaining individuals are stronger. However, I can rule out that there is significant selective mortality because the first autoregressive coefficient is estimated to be 0.17 (not negative). The positive autocorrelation might be interpreted as omitted regressors that are positively correlated over time. For example, one could think of health care infrastructure such as number of hospitals or doctors.

In particular, the probability of dying for an individual with more than 12 years of education is between 0.56% and 0.59% smaller than the probability for an individual whose education level is less than one year. However, in the random effect model, individuals who are professionals have a higher probability of dying and the probability of dying is 0.68% higher for professionals compared to individuals who are unemployed when the other variables are held constant.

Table 3-6 Robust estimation with income equivalent scale 1†.

	Fixed Effects		Population Averaged	
	Coef.	Robust Std. Err.	Coef.	Semi-robust Std. Err.
Mean of log disposable income	-1.591	1.276	-1.639	1.242
Mean of square log disposable income	0.089	0.064	0.092	0.063
Gini coefficient	0.246	0.213	0.193	0.957
Age	-0.394	0.213	-0.393	0.204
Square of age	0.007*	0.003	0.007**	0.003
Gender	1.617	2.498	1.627	2.482
Education				
Edu 2(1 - 6 years)	-1.646	1.278	-1.552	1.187
Edu 3(7 – 9 years)	1.049	2.397	1.336	2.226
Edu 4(10 – 12 years)	-0.346	1.969	-0.104	1.878
Edu 5(More than 12 years)	-5.729**	1.806	-6.044**	1.761
Occupation††				
Occu1	6.512	3.295	6.706*	3.149
Occu2	-0.915	2.587	-1.351	2.527
Occu3	0.145	3.144	-0.416	3.05
Occu4	-1.616	1.771	-1.887	1.725
Occu5	-1.03	1.339	-0.586	1.292
Occu6	2.378	2.048	1.67	1.871
Constant	14.841	7.387	14.896*	7.229
R^2	0.47		-	
N	655			

† The equivalent scale is the number of household members.
†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.
* significant at 5% level; ** significant at 1% level

As expected, age appears as a significant determinant of the probability of dying. The relationship is nonlinear and the turning point of age is 28. An increase of age induces a decrease in the individual probability of dying before the age of 28.

After this age, the relationship becomes positive. However, there is no significant evidence for the effect of gender. Table 3-7 shows that results are similar when the income equivalent scale 1 is replaced by income equivalent scale 2.

Table 3-7 Robust estimation with income equivalent scale 2†.

	Fixed Effects		Population Averaged	
	Coef.	Robust Std. Err.	Coef.	Semi-robust Std. Err.
Mean of log disposable income	-1.251	1.389	-1.291	1.354
Mean of square log disposable income	0.071	0.067	0.073	0.066
Gini coefficient	0.036	1.055	-0.007	0.991
Age	-0.394	0.214	-0.393	0.204
Square of age	0.007*	0.003	0.007**	0.003
Gender	1.703	2.485	1.714	2.47
Education				
Edu 2(1 - 6 years)	-1.627	1.313	-1.534	1.213
Edu 3(7 – 9 years)	1.029	2.395	1.309	2.227
Edu 4(10 – 12 years)	-0.31	2.018	-0.066	1.927
Edu 5(More than 12 years)	-5.562**	1.824	-5.874**	1.778
Occupation††				
Occu1	6.574	3.319	6.767*	3.171
Occu2	-0.525	2.565	-0.948	2.513
Occu3	0.195	3.126	-0.366	3.032
Occu4	-1.518	1.754	-1.789	1.711
Occu5	-0.991	1.335	-0.546	1.291
Occu6	2.312	2.065	1.607	1.883
Constant	13.081	8.119	13.087	7.969
R^2	0.47		-	
N	655			

† The formula of equivalent scale is (number of adult + 0.5* number of children)$^{0.9}$.
†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.
* significant at 5% level; ** significant at 1% level

The results presented in fix-effects and random-effects estimation are similar and the Hausman test[14] indicates that two estimations are consistent, which implies the omitted variables are uncorrelated to the regressors in the estimation. It means the unobserved county characteristics are uncorrelated to average income level, average

[14] The Hausman test is implemented under fixed-effects and population averaged estimations without robust standard error. The null hypothesis is two estimations are all consistent estimations whereas the alternative is only fixed-effects estimation is consistent.

age of residence, Gini coefficient, gender proportion, average education level, and industrial property.

Finally, the estimated coefficient on the Gini is sensitive to the different equivalence scales as can be seen in Table 3-6 and Table 3-7. Evidence that the Gini coefficient is sensitive to income equivalence scales has also been found in other studies (Buhmann et al., 1988; Coulter et al., 1992; Pascual et al., 2005). The main difference between the two equivalence scales used in this chapter is the financial weight placed on children in the household. In general, a good equivalence scale should reflect both economies of size and differences in household characteristics such as location and age and health of members (Coulter et al, 1992). Coulter et al. (1992) also suggest that a household with three adults does not have the same financial demands as a household with one mother and two children. It may be preferable to use an equivalence scale that treats adults and children differently, thus, the results presented in Table 3-7 may be more appropriate than those shown in Table 3-6.

3.6.2 Robustness checks

3.6.2.1 The effect of long-run income and long-run income inequality

It is plausible that income and income inequality have a lagged effect on health. For example, people being poor during childhood might have a higher probability to suffer from worse health status in their adulthood because of malnutrition and other reasons. Income inequality may affect the health in the following periods through social status, for example, social stability. Taking these factors into consideration, the long-run log income variable and long-run Gini coefficient which are the mean of log income and Gini coefficient across the time span of the data[15] are created. Since these two created variables are time in-variant, the

[15] There are 23 districts in the data set. Hence, the observations of long-run log income

Hausman and Taylor (HT) estimation[16] is used and the result is shown in Table 3-8. The HT method allows us to estimate the impact of time-invariant regressors that are correlated with the individual effect. This contrasts with fixed effect estimation, which does not allow for time-invariant regressors. To be able to carry out HT estimation, we need to decide which regressors are potentially correlated with the individual effect (these are called endogenous) and which ones are not (these are called exogenous). In the HT method, several instruments can be created from each exogenous regressor, by exploiting the time variation (Wooldridge, 2002 (Section 11.4)). Here the emphasis is in allowing long-run and short-run disposable income to be correlated with the individual effect (i.e. endogenous). Table 3-8 presents the results for all types of regressors.

For both equivalence scales, age, age square term, Edu5, and Occu1 are all individually significant at 1% and 5% respectively whereas the log income and its square term are not significant at 5% level. This result is similar to those in Table 3-6 and Table 3-7. However, long-run Gini has a significantly positive effect on crude mortality but long-run income has a significantly negative effect. When the long-run mean of Gini coefficient increases 1 unit, the probability of dying will increase 3.6% for 4.1%, holding other variables constant. When the long-run mean of log disposable income increases 1 unit, the probability of dying will reduce 0.26% for 0.27%, holding other variables constant. Furthermore, log disposable income and its square term are jointly significant, though their separate *z*- test cannot reject the null hypothesis.

variable are 655 but they only have 23 values.

[16] Hausman and Taylor estimation requests that all panels must start at the same period. There are two countries in the dataset which start from the 7th period. I drop these two counties from the dataset because only 46 observations are removed. If the initial 6 periods of 21 counties were removed instead, the number of removed observations would amount to 126.

Table 3-8 Hausman and Taylor Estimation

	Income equivalent scale 1		Income equivalent scale 2	
	Coef.	Std. Err	Coef.	Std. Err
Time variant exogenous				
Gini coefficient	0.394	0.814	0.235	0.816
Age	-0.342**	0.117	-0.346**	0.117
Square of age	0.006**	0.001	0.007**	0.001
Gender	1.593	1.715	1.671	1.718
Education				
Edu 2(1 - 6 years)	-1.21	1.166	-1.154	1.168
Edu 3(7 – 9 years)	0.84	1.622	0.838	1.626
Edu 4(10 – 12 years)	0.167	1.579	0.289	1.601
Edu 5(More than 12 years)	-5.071**	1.698	-4.906**	1.694
Occupation†				
Occu1	7.429*	3.014	7.408*	3.022
Occu2	-2.524	2.073	-2.053	2.064
Occu3	-2.824	2.271	-2.677	2.273
Occu4	-1.778	1.601	-1.664	1.603
Occu5	-1.003	0.874	-1.011	0.876
Occu6	1.245	1.311	1.25	1.316
Time variant endogenous				
Mean of log disposable income	-1.388	1.046	-1.039	1.157
Mean of square log disposable income	0.077	0.049	0.059	0.052
Time invariant exogenous				
Long-run mean of Gini	41.146**	9.707	35.618**	9.091
Time invariant endogenous				
Long-run mean of log disposable income	-2.57**	0.904	-2.744**	0.923
Constant	30.94	12.465	34.345	13.091
Wald chi²	1863.9		1856.39	
N	609			

† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.
* significant at 5% level; ** significant at 1% level

3.6.2.2 The transmission channel from income and income inequality to health.

Education is always a factor considered in the literature of income inequality. Education is a determinant of the earning distribution and the earning distribution is one of the components in the income distribution (Lam and Levison, 1992; De Gregorio and Lee, 1999; Checchi, 2001). Thus, education has a direct effect on income and income inequality. On the other hands, education also correlates with occupation. Martins and Pereira (2004) find that in the higher skilled worker group, individuals with higher education attainment get higher educational returns.

Furthermore, it is possible that education and occupation are the main channels through which income and income inequality affect health. In addition, although income shocks will lead to changes in education, the latter is likely to have only a long-run impact on regional incomes. Thus, on the assumption that the fixed effects will capture the long-run effect of education, one could consider leaving the educational variables out of the regression. This is shown in Table 3-9.

Table 3-9 shows that age and its square term are significant at 1% level. The mean of log disposable income and its square term are still not significant at 5% level respectively. However, the collinearity between these two variables might affect the precision of estimates. Thus, the joint test equalling zero is credible as the evidence against the absolute income hypothesis. The F-test for joint significant of both variables rejects the null hypothesis at 5% confident level.

After the robustness checks we can confirm that the effects of age and Edu5 on crude mortality are significant. Age has a nonlinear association with crude mortality rate and the effect of education is coherent with a large body of literature which supports that the educational attendance has a positive association with health.

However, even though we found before that the three income-related variables were jointly non-significant, we now find that they are significant. The Hausman-Taylor estimation shows that not only long-run income is significant, but also current income and its square are jointly significant (although not individually). The Gini coefficient does not appear to be significant in any of these estimations, and the reason for this might be the low power of the significance test due to high correlation between the income-related variables. However, the pairwise correlation coefficient of income relevant variables is not large[17]. Thus, this reason could be excluded. Finally, the occupational effect is ambiguous.

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[17] The correlation coefficient between Gini and ln(income) and $[\ln(\text{income})]^2$ calculated by

Table 3-9 Robust estimation with fixed effects

	Equivalent Scale 1		Equivalent Scale 2	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Mean of log disposable income	-0.618	1.269	-0.319	1.378
Mean of square log disposable income	0.047	0.063	0.032	0.066
Gini coefficient	0.314	1.131	0.053	1.176
Age	-0.511**	0.16	-0.505**	0.159
Square of age	0.008**	0.002	0.008**	0.002
Gender	1.561	2.321	1.654	2.301
Occupation††				
Occu1	0.745	3.394	0.95	3.41
Occu2	-3.143	2.475	-2.833	2.399
Occu3	-2.366	2.967	-2.27	2.936
Occu4	-1.283	1.834	-1.215	1.807
Occu5	-0.757	1.237	-0.736	1.223
Occu6	4.519	2.364	4.387	2.388
Constant	10.205	7.51	8.431	8.248
R^2	0.367		0.369	
N	655			

† The equivalent scale is the number of household members. Equivalent scale 2 is (number of adult + 0.5* number of children) $^{0.9}$.
†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.
* significant at 5% level; ** significant at 1% level

3.6.2.3 Nonlinear check of income inequality on mortality

Some literature has provided the evidence that the relationship between health outcome and income is nonlinear. The same argument can be applied in the case of income inequality. After taking the possible nonlinear effect of income inequality on mortality into consideration, I cut Gini variable into 4 quartiles according to the ranking of Gini coefficient. Gini1 is assigned to 1 if the county's Gini coefficient is in bottom quartile and 0, otherwise. Gini2 is assigned to 1 if the county's Gini coefficient is in the range between 25% and 50%; 0 otherwise. Gini3 is assigned to 1

equivalent scale 1is 0.1226 and 0.1248, respectively. The correlation coefficient is 0.312 and 0.3156, respectively, when the three variables are calculated by equivalent scale 2. Meanwhile, we also drop $[\ln(\text{income})]^2$ from regression, and the Gini coefficient is positive but not significant at 5% level. Further, we drop ln(income) and its square term from regression, Gini still remains positive but not significant at 5% level.

if the county's Gini coefficient is in the range between 50% and 75%; 0 otherwise. Gini4 is assigned to 1 if the county's Gini coefficient is in upper quartile and 0, otherwise. Only Gini2, Gini3, and Gini4 enter the regressions. The results are shown in Table 3-10 and Table 3-11. In both tables, the Gini dummies are not significant at 5% level and the other results are similar to those in Table 3-6 and Table 3-7.

Table 3-10 Robust estimation with income equivalent scale 1†

	Fixed Effects		Population Averaged	
	Coef.	Robust Std. Err.	Coef.	Semi-robust Std. Err.
Mean of log disposable income	-1.542	1.193	-1.576	1.182
Mean of square log disposable income	0.087	0.06	0.09	0.059
Gini dummy				
Gini2	-0.064	0.039	-0.068	0.038
Gini3	0.063	0.06	0.06	0.058
Gini4	0.031	0.068	0.03	0.065
Age	-0.397	0.211	-0.396	0.205
Square of age	0.007*	0.003	0.007**	0.003
Gender	1.515	2.45	1.511	2.467
Education				
Edu 2(1 - 6 years)	-1.587	1.159	-1.497	1.087
Edu 3(7 – 9 years)	0.856	2.329	1.13	2.203
Edu 4(10 – 12 years)	-0.154	1.901	0.087	1.839
Edu 5(More than 12 years)	-5.698**	1.642	-6.017**	1.619
Occupation††				
Occu1	6.411	3.135	6.606*	3.04
Occu2	-1.135	2.413	-1.551	2.406
Occu3	-0.219	2.998	-0.778	2.97
Occu4	-1.969	1.734	-2.248	1.721
Occu5	-0.985	1.314	-0.545	1.291
Occu6	2.409	2.031	1.707	1.888
Constant	14.66	7.035	14.633	6.991
R^2	0.48		-	
N	655			

† The formula of equivalent scale is (number of adult + 0.5* number of children)$^{0.9}$.

†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.

* significant at 5% level; ** significant at 1% level

Table 3-11 Robust estimation with income equivalent scale 2[†]

	Fixed Effects		Population Averaged	
	Coef.	Robust Std. Err.	Coef.	Semi-robust Std. Err.
Mean of log disposable income	-1.173	1.334	-1.197	1.323
Mean of square log disposable income	0.067	0.065	0.069	0.064
Gini dummy				
Gini2	-0.037	0.039	-0.043	0.037
Gini3	0.059	0.066	0.056	0.063
Gini4	0.06	0.079	0.057	0.075
Age	-0.406	0.216	-0.404	0.209
Square of age	0.007*	0.003	0.007**	0.003
Gender	1.545	2.454	1.545	2.476
Education				
Edu 2(1 - 6 years)	-1.688	1.225	-1.603	1.154
Edu 3(7 – 9 years)	1.097	2.34	1.373	2.215
Edu 4(10 – 12 years)	-0.194	1.949	0.056	1.885
Edu 5(More than 12 years)	-5.59**	1.769	-5.924**	1.751
Occupation††				
Occu1	6.55	3.218	6.769*	3.115
Occu2	-0.583	2.415	-0.993	2.409
Occu3	0.152	3.003	-0.404	2.966
Occu4	-1.725	1.704	-2.006	1.683
Occu5	-0.934	1.333	-0.482	1.307
Occu6	2.534	2.101	1.819	1.955
Constant	12.891	7.848	12.798	7.827
R^2	0.48		-	
N	655			

† The formula of equivalent scale is (number of adult + 0.5* number of children)$^{0.9}$.
†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.
* significant at 5% level; ** significant at 1% level

3.7 Conclusion

This chapter concerns the socioeconomic determinants of mortality, with a particular focus on the absolute income and income inequality hypotheses, using a novel approach to avoid aggregation bias. Following a recent strand of epidemiological literature (Sheppard and Prentice, 1995; Salway and Wakefield, 2005), I combined individual level data on income and other socio-economic characteristics with aggregate data on mortality. When compared with using individual-level data for both mortality and regressors, the proposed approach has the disadvantage that it cannot control for unobserved time-invariant characteristics. However, it has an advantage over the aggregate studies that have neglected non-linear links at the individual-level data model. The evidence is found to support the absolute income hypothesis and the income inequality hypotheses in Taiwan. This result is partially consistent with the findings of Chiang (1999). However, the long-run Gini and long-run income has a significantly effect on health rather than current Gini coefficient and income. One plausible explanation for this result is little cross-section variation in income variable and Gini coefficient at county level. The results also confirm the positive effects of education on the health of individuals whereas the evidence on occupational effects on health is ambiguous. In addition, I also use different income equivalent scales and find that it is not a sensitive factor in our analysis.

An important issue which is not dealt with in this chapter due to data limitation is age factor because detrended age is surely correlated with life expectancy and other health measures. I will leave this issue in the future research. Future research might also estimate the impact of income inequality on groups of different income or educational level.

Chapter 4. The health income relationship of the elderly population in Taiwan

4.1 Introduction

The influence of income on health status attracts the interest of some researchers. However, there are no consistent conclusions concerning the income hypotheses, especially the absolute income hypothesis and the income inequality hypothesis. A large literature claims income inequality replaces absolute income as the significant determinant of health in the developed countries. Absolute income is only more influential in the developing countries. Although the nonlinear association between income and health is usually presumed in the regression analyses, very few studies delve into the relationship between income and health and the conclusions are mixed. The studies which do not provide the evidence for the absolute income hypothesis usually ignore the relationship between income and health. However, it is also the case even with studies that support the absolute income hypothesis.

Understanding the relationship between income and health can not only shed light on income-related health inequality, but also provide a strong basis for the test of health income hypotheses. Furthermore, it is able to provide a blueprint for policy makers. For instance, if the relationship is linear, the policy of income redistribution would not have a significant effect on improving the average health status of society. The average health status of a whole society remains constant when the income flows from high tail to low tail of income distribution. However, if the relationship is nonlinear, policies can focus on the disadvantaged groups to promote the average health status. On the other hand, the relationship between income and health can disentangle whether the conclusions of the health income hypotheses test are artificial owing to the aggregate bias (Gravelle et al., 2002) or convincing.

The literature investigating the health income relationship usually employs parametric estimations, particularly, Probit form and the quadratic form. It will produce exact estimators if the functional form of the conditional mean is known. If the function form of the conditional mean is not manifest, misspecification will generate incorrect estimators. In practice, the functional form is usually unknown. Nonparametric estimations are another option for overcoming the problem of misspecification, they can help detect subtle changes in the health income relationship as income varies, which reveals more detailed information of income related health inequality. Though in this case there does not appear to be systematic changes in the relationship across income levels.

Nonparametric kernel regression and two semi-parametric estimations, partially linear regression and single index regression, are used in this chapter to investigate the health income relationship using micro (household) data. Meanwhile, the health income relationship in the top quartile, bottom quartile, and middle two quartiles of income distribution is estimated to understand the relationship at different income levels. Finally, the model specification test proposed by Li and Racine is implemented to diagnose whether the parametric quadratic form and cubic form in terms of income are a properly parametric model to describe the nonlinear health income relationship. The average derivative estimators produced only by semi-parametric single index model are directly comparable to those produced by parametric Probit and Ordinary Least Square estimations.

This chapter is organised as follows. Section 2 covers the literature review and motivation. Section 3 provides the data introduction. Section 4 implements nonparametric kernel regression and section 5 is devoted to semi-parametric regression. Section 6 constitutes the conclusion.

4.2 Previous Studies and Motivation

4.2.1 Previous Studies

In previous studies, different methods were used to estimate the relationship between health and income whether with macro-level data or with micro-level data. The measures of health and income also influence the results. Preston (1975) shows the concave pattern between life expectancy at birth and national income per head using international analysis. The life expectancy curve rises more steeply in the lower range of national income than in the higher range. National income does not seem a determinant of life expectancy in developed countries. A number of later studies using aggregate data claim income distribution becomes a more crucial determinant than income once countries become affluent. Hence, the relative income hypothesis attracts more attention than the absolute income hypothesis. The studies advocating the relative income hypothesis or income inequality hypothesis claim that countries with more egalitarian income distributions have lower death rates (Rodgers, 1979; Wilkinson, 1986, 1992a). However, Gravelle et al. (2002) mathematically demonstrate that it cannot be inferred that income inequality or relative deprivation affects individual mortality risk when the individual mortality risk-income association is nonlinear. At the time of writing, the debates around these income hypotheses are still going on.

In the past two decades, researchers turned to using micro-data to analyse the relationship between health and income rather than macro-data. The advantage of the micro-level research is that it is able to avoid the aggregate problem caused by macro-level data, especially income variables. Backlund et al. (1996) use the National Longitudinal Mortality Study (NLMS) as well as the Cox Proportional Hazards Model to estimate the income-mortality gradient which assumes income is a determinant of mortality and it has a negative relationship with mortality. Their conclusion posits that the gradient is much smaller at high income levels than at low to moderate income levels amongst subjects of working age (25 to 64 years). This circumstance also holds in elderly populations even if the other socioeconomic variables have been controlled for. However, the gradient is greater in the case of working-age women at extreme poverty levels compared with women in other income levels. The gradient is much smaller in the elderly than in the working-age population. However, Martikainen et al., (2001) using household income and the socio-demographic factors from the Finnish tax authorities and from the 1990 census, find the association between mortality and income is nearly linear.

With respect to other health measures, Blaxter (1990) investigates the association between health and income and concludes that the relationship between income and health becomes apparent along three different gradients. One is at levels of extreme poverty; another is at low to moderate income levels; and the other is at high income levels. Fritzell et al. (2004) use the Swedish Living Condition Survey and logistic regression including polynomial terms of income. The curvilinear association between self-rated health and income is revealed in their analyses. Ecob and Smith (1999) use the Health and Lifestyle Survey (HALS) conducted in England, Scotland and Wales and the procedures generalized linear model and logistic model to estimate the association. They find that the association between health and income is approximately linear within the 10th and 90th percentile distribution of income whether or not controlling for socioeconomic variables. Rahkonen et al. (2000) and Rahkonen et al. (2002) use Finnish data and also support the more linear association between health and income. Mackenbach et al. (2005) use the data from nationally representative health, level of living or similar surveys from Belgium, Denmark, England, Finland, France, the Netherlands and Norway as well as the techniques of LOESS-function which is a locally weighted regression smoother and spline regressions to conduct their analysis. They find that a higher household equivalent income is associated with better self-rated health among men and women in all countries. In four countries (Belgium, Finland, the Netherlands, and Norway) the gradient at the lower income level is steeper than at a higher income level. In summary, the conclusion concerning the nature of the health income relationship is different from country to country. Difference in data sets is also a determinant of the conclusion. More and more studies tend to indicate that micro-level data produces a more precise health income relationship.

4.2.2 Motivation

Understanding the shape of the individual-level association between income and health is important for several reasons. First, it can shed light on income-related health inequality. If the association is strongly curvilinear, it is in the sense that health declines much more rapidly at a lower income level than that at a higher income level. It implies that income has a direct correlation with health. However, if the association is more linear in nature, then health declines at a constant rate with declining income. Income may not have a direct correlation, but rather an indirect one with health through subtle mechanisms, for example, behavioural and psychosocial factors. Income may be just a proxy for other characteristics such as education levels and occupational classes. The Whitehall study is a typical example. Whitehall II Study (2004) reveals the impact of socioeconomic status after controlling for social class. Senior civil servants have better health status than junior civil servants due to decreased stress or greater achievements, instead of income per se. The correlation also provides an insight for policy makers. When the association at individual levels is strongly curvilinear, the problem of how to make income distribution more equal is a task for policy makers. A more equal distribution of income will raise the average health status of the population in a given region.[18] However, when the association is

[18] If the association between income and health is strongly curvilinear, the marginal health status at lower income levels is higher than that at higher income levels. Moving some income from higher income levels to lower income levels will increase the average health status because the marginal health status reducing at higher income levels is less than that increasing at lower income levels.

more linear, the income related health status of individuals in a region is like a zero-sum game. The magnitude of health reduced by taking income from the individuals at high income level is equal to the magnitude of health increased by giving the income to the individuals at lower income level. Under this circumstance, the aggregate health status will not change if income redistribution policies are implemented. Hence, the question of how to break down the boundary between social or occupational classes, how to increase income mobility, or how to relieve mental stress is a goal for policy makers. Second, the association between health and income at individual level can also provide an indication of whether the conclusions made by previous related studies in the Taiwanese case in testing the relative hypothesis (or income inequality hypothesis) are correct in terms of the aggregate bias.

In the above studies, the authors use parametric estimation to examine the relationship between health and income. Under parametric estimation, the functional form of the conditional mean is supposed to be known. Unfortunately, it is usually unknown in practice. Nonparametric estimation relaxes the assumption that the conditional mean function is known to avoid misspecification and it also can avoid unobserved heterogeneity. Jones and Wildman (2008) employ parametric and semi-parametric estimation to test the income effect on health using the British Household Panel Survey (BHPS). They produce evidence that income has a strong impact on self-reported health for men and women in their parametric estimation. They use a semi-parametric partially-linear model which relaxes the assumption of a specific functional form of income and obtain robust evidence to support the relative deprivation hypothesis.

This chapter estimates the shape of the relationship between income and health by using nonparametric and semi-parametric methods applied to the Health and Living Status of the Elderly in Taiwan (SHLE) conducted in 1989 and 1996. The average derivative estimator (ADE) is also estimated to acquire the coefficient of income variable. Finally, the modelling test for nonparametric and parametric estimations is implemented to understand which method is appropriate to fit the real relationship. Understanding the relationship between health and income can not only provide insight for policy makers, but can also clarify the conclusions of related studies using aggregate data.

4.3 Data

The data used in this chapter is from the Survey of Health and Living Status of the Elderly in Taiwan. This survey is designed to be a benchmark to measure the future changes in health and living status of the elderly and provide a resource for a number of descriptive and analytic studies of the elderly. Furthermore, it also sheds light on health status of elderly people for policy makers.

This survey comprises eight sections as follows: 1. Marital history and other characteristics of background; 2. Household schedule, social and economic exchanges; 3. Health, health care utilization and behaviour; 4. Occupational history; 5. Activities and general attitudes; 6. Residence history; 7. Economic/financial wellbeing; 8. Emotional and instrumental support. It contains not only the significant historical information with respect to marital status, employment and retirement, and living arrangement/residence, but also the information of the exchanges in material and emotional support between the elderly and other family members or friends. To this end, detailed characteristics of all household members and of close relations living elsewhere are available. With respect to health information, in addition to the level of disability and illness, the questionnaire also concerns health care utilization in Taiwan as well as a series of questions on health care behaviour including consumption of alcoholic beverages, smoking and aspects of diet. A section is devoted to the financial status of the elderly, the source of their income and its adequacy, their asset structure, management of finances and whether the degree of control over property and its disposition is affected by concern about future support.

This survey is a panel survey including six waves conducted in 1989, 1993, 1996, 1999, 2003, and 2007. The samples are based on individuals aged 60 and older and the 4,049 observations are included in the first wave. In 1996, this survey added a cohort of 50-66 year-olds to replenish in the light of attrition within the original samples and added a further cohort of 50-56 year-olds in 2003. This data set possesses the properties of cohort and panel data. In this chapter, the first wave (1989) and the third wave (1996) data are used because of data consistency with the next chapter. In this chapter, the focus is on the health income relationship in the elderly group. Therefore, the age range of the samples in both years in the analysis is between 60 and 80 years old. The total samples in both years are 3235 and 2170, respectively; the two waves are pooled because the property of nonparametric estimation requires a large sample to achieve a more precise result.

The chapter focuses on the relationships between self-assessed health status (SAH), the mental health measurement designed by CES-D (Centre for Epidemiological Studies – Depression), and life satisfaction (LS) and income respectively. In the health status questionnaire, the question ‘In general, would you say your health is excellent, very good, good, fair, or poor?’ is used to determine self-assessed health status and it converts to a dichotomous variable which is assigned 1 if the responses are excellent and very good and 0, otherwise. Although the measurement of self-assessed health status in the Survey of Health and Living Status of the Elderly is not as detailed as that in Short Form 36 (SF-36), it is still a good indicator of mortality and used in many studies (Shibuya et al., 2002; Soobader and LeClere, 1999; Kennedy et al., 1998 and Kahn et al., 2000).

CES-D measures the degree of depression symptoms and uses a numerical scale between 0 and 30. There are 17 questions in CES-D in the survey of 1989 and 10 questions in the survey of 1996. In order to make it comparable, ten identical questions are selected from two waves. CES-D comprises four domains, depressed affect, somatic symptoms, positive effect and interpersonal difficulties. Each question has four options, never, barely, sometimes and frequently and they are assigned the score for 0, 1, 2 and 3 respectively (see Table A-4). After these questions are summarized, a higher score indicates more depression which also implies poorer mental health generally. Ten questions are included in the questionnaire on life satisfaction. The responses are “Yes” and “No”. The answer “Yes” is assigned 1 and 0, otherwise (see Table A-5). The scale for life satisfaction is between 0 and 10. Life satisfaction can also be regarded as a measure of happiness (Layard et al. 2008). The measure of depression focuses on the status at a specific point (the current mental status) whereas a longer time span (i.e. the comparison of current status with the past, the evaluation of the whole life, and the expectation of future) is concerned in the measure of life satisfaction in terms of time span.

With respect to the income variable, it is an ordinal categorical variable in this dataset. However, the income scales in the 1989 and 1996 questionnaires are not identical. The income scale in the questionnaire of 1989 is monthly income whereas it is annual income in the questionnaire of 1996. In order to simplify the analysis and avoid the problem of income scales, interval regression is applied to obtain a continuous income variable. Before implementing interval regression, the sample is partitioned into two sub-groups. One is the working group and the other one is the non-working group. The explanatory variables in the working group include age, square of age, educational year, the number of children, dummy variables for marital status, dummy variables for job type, dummy variables for income source (from children and relations, from pension, and from rent, gain of investment, and gain of interest, and dummy variables for regions. The explanatory variables in the non-working group are the same as those in the working group but dummy variables for job type are dropped. The results of interval regression in 1989 and 1996 are shown in Table A-6 and Table A-7. The predicted income has been checked and no sample is outside of its interval.

The regressors included in the estimations of semi-parametric estimations are gender, age, education year, and marital status.

Table 4-1 Summary Statistics for Pooled SHLE 1989, 1996

Variable	Mean	Std. Dev.
Self-Assessed Health (SAH)	0.623	0.485
Depression (CES-D)	6.479	4.596
Life Satisfaction (LS)	6.281	2.515
Income (in thousand)	14.693	14.731
Square of Income	432.848	1103.534
Working	0.29	0.454
Job Type		
Farming	0.306	0.461
High Skill Worker	0.057	0.231
Senior Manager	0.168	0.374
Clerk	0.061	0.24
Sales Clerk	0.047	0.212
Craftsman	0.091	0.287
Semi-skill Worker	0.07	0.254
Service	0.129	0.336
Non-skill worker	0.067	0.25
Income Source		
From Children and Relations	0.670	0.610
From Pension	0.354	0.724
From Rent, Investment Gain, and Interest	0.168	0.374
Number of Children	4.596	2.182
Age	68.131	5.421
Sex†	0.561	0.496
Education Year	4.116	4.39
Marital Status		
Married	0.683	0.465
Divorced	0.027	0.162
Widowed	0.264	0.441
Single	0.025	0.158
Region		
North	0.279	0.448
Middle	0.333	0.471
South	0.317	0.465
East	0.072	0.258
N=5405		

† The mean gender dummy variable presents the proportion of male.

Table 4-1 presents the summary statistics from which the variables are used in the estimations in this chapter. The mean of self-assessed health is 0.623 which means that 62.3% observers report their health status is excellent or very good. The average scale of depression and life satisfaction is 6.479 points and 6.281 points respectively. The monthly average income is NT$14,693 (New Taiwan Dollar)[19]. The proportion of working observations among the sample is 29%. The other dummies are transformed to variables in proportion. For instance, 67%, 35.4 %, and 16.8 % observations report respectively that their income source is from children and relations, from pension, and from rent, investment gain, and interest. However, the sum of these three variables is more than 1. Some observations report that their income source is from more than one source.

Table 4-2 Sample Cross Tabulation

CES-D \ LS	0	1	2	3	4	5
< 6.479	9	40	112	215	242	279
>= 6.479	34	149	189	222	178	223
Total	43	189	301	437	420	502

CES-D \ LS	6	7	8	9	10	Total
< 6.479	381	589	625	627	234	3353
>= 6.479	193	253	299	241	88	2069
Total	574	842	924	868	322	5422

Note: The mean scale of CES-D and LS is 6.479 and 6.281 respectively.

Table 4-2 shows the cross-tabulation of sample in terms of CES-D and LS. In the table, the scale of 6.479 is the mean scale of CES-D. The relatively depressed group is defined by the score which is above or equal to mean. Below the scale 5 of life satisfaction, the relatively depressed observations are more than counterpart. When the scale of life satisfaction equals to 4 or more, the observations are more in the counterpart than in the relatively depressed group. When the scale of life

[19] In 1989 1GBP was equal to NT$43.032 and it was NT$42.822 in 1996.

satisfaction goes up, the number of observations in the relatively depressed group goes down whereas the number of observations in the counterpart goes up. This indicates that the relatively depressed people have lower life satisfaction.

4.4 Econometric Frameworks

4.4.1 Nonparametric Kernel Regression

Regression methods model the expected behaviour of the dependent variable *y* given by a vector of covariates denoted by *x*. They not only help researchers or policy makers to produce the predicted mean of y but also to know how the dependent variable responds to the change in one or more independent variables. The widely applied parametric regressions include some unknown parameters and the functional form of the conditional mean is given. For example, a model based on a conditional mean, $g(x, \beta)$, may be posited to be a linear or nonlinear function such as OLS and Probit. The x is a vector of covariates and β is a finite number of unknown parameters. If the presumed function form is correct, the parametric regressions will produce precise estimators. However, in practice, the true functional form of regression is rarely known. These parametric estimations may lead to the inconsistence due to severe misspecification. Hence, nonparametric regression is an option to avoid this problem.

Nonparametric estimations do not require the presumption of functional form but some other presumptions such as smoothness and moment conditions are necessary. However, this does not come without a cost. This method requires a larger sample size to achieve the same degree of precision as a correctly specified parametric regression. Choosing between parametric and nonparametric estimations entails a trade-off between large sample size and misspecification.

This chapter begins by considering the nonparametric regression model as

$$(4.1) \quad Y = g(X) + \varepsilon$$

where ε is the random error term and defines $E(\varepsilon|x)=0$. The sample realizations (Y, X) are i.i.d. In this chapter Y and X are the measures of health status and income at individual level, respectively. The $g(\cdot)$ is the function of individual income which is unspecified. Nonparametric regression analysis avoids the restrictions of any parametric assumption on the regression function and the aim is to produce a reasonable approximation to the unknown response function $g(\cdot)$.

4.4.1.1 Kernel Density Estimation

The general form of for the kernel density estimator of a q-dimensional variable x is

$$(4.2) \quad \hat{f}(x) = \frac{1}{nh_1 \dots h_q} \sum_{i=1}^{n} K\left(\frac{X_i - x}{h}\right)$$

where $K\left(\frac{X_i - x}{h}\right) = k\left(\frac{X_{i1} - x_1}{h_1}\right) \times \dots \times k\left(\frac{X_{iq} - x_q}{h_q}\right)$ and where $k(\cdot)$ is a univariate kernel function. Simplify Eq. (4.2) to univariate kernel density estimator and show in Eq. (4.3).

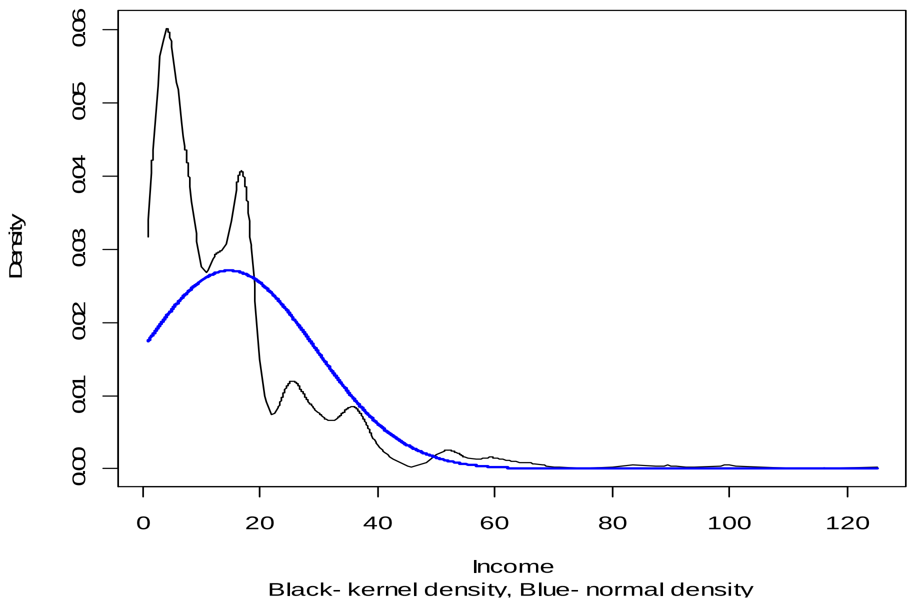
$$(4.3) \quad \hat{f} = \frac{1}{n} \sum_{i=1}^{n} k\left(\frac{X_i - x}{h}\right)$$

Eq. (4.3) reveals that the kernel density estimator evaluated at x for a given bandwidth h is simply a weighted average of the data and the weight is greater when the observations are close to the point at which the density is estimated.

4.4.1.2 An Application

A Gaussian kernel with the bandwidth chosen according to Silverman's rule of thumb (Silverman, 1986) for a density is used in Figure 4.1[20] It tells us that the difference exists between kernel density and normal density.

Figure 4.1 The Density Estimation of Log Income (Kernel: Gaussian, Bandwidth: 0.2)



4.4.1.3 Kernel Regression

The aim of kernel regression is to replace $g(X)$ in Eq. (4.1) with a local estimator of the conditional mean

$$(4.4) \quad g(x) = E[Y|X = x] = \int y f(y|x) dy$$

where $f(y|x)=f(x,y)/f(x)$ is a conditional density of y. Hence, Eq. (4.4) can be rewritten as

[20] This figure is produced by R. The following estimations and figures are also produced by R.

$$(4.5) \quad E[y \mid x] = \frac{\int y f(x,y) dy}{f(x)}$$

The estimator of $g(x)$ is available if one knows how to estimate $f(x,y)$ and $f(x)$. The kernel regression uses the estimators based on locally weighted estimation to replace the numerator and denominator in Eq. (4.5). The kernel estimators of numerator and denominator are denoted by $\int y \hat{f}(x,y)dy$ and $\hat{f}(x)$, respectively. The Eq. (4.4) is rewritten as

$$(4.6) \quad \hat{g}(x) = \frac{\frac{1}{n}\sum_{i=1}^{n} k(\frac{X_i - x}{h})Y_i}{\frac{1}{n}\sum_{j=1}^{n} k(\frac{X_j - x}{h})} = \frac{\sum_{i=1}^{n} k(\frac{X_i - x}{h})Y_i}{\sum_{j=1}^{n} k(\frac{X_j - x}{h})} = \sum_{i=1}^{n} Y_i w_i$$

where $w_i = k(\frac{X_i - x}{h}) / \sum_{j=1}^{n} k(\frac{X_j - x}{h})$ is the weight attached to Y_i. The weights are positive and sum to one.

4.4.1.4 Bandwidth Selection

In the kernel regression models two factors will affect the estimations. One is the univariate kernel form and the other is the selection of bandwidth. The univariate kernel function occurs in several functional forms and the common choices are the Gaussian and the Epanechnikov. However, the choice of bandwidth is more sensitive to the results than that of kernel functional form. It determines the appearance and properties of the final density estimate. On the other hand, the selection of bandwidth entails the trade-off between the bias and variance of the estimates. Given the sample size n, the estimators will have a smaller bias but a larger variance when the bandwidth is small whereas the estimators will have a larger bias but a smaller variance if the bandwidth is large.

Silverman (1986) suggests the "normal reference rule-of-thumb" approach which generates the optimal bandwidth for a particular family of distributions. The bandwidth approximately equals to $1.06\sigma n^{-1/5}$.

Another method, least square cross-validation, possessing the data-driven property is as Eq. (4.7).

$$(4.7) \quad CV(h) = n^{-1}\sum_{i=1}^{n} M(X_i)(Y_i - \hat{g}_{-i}(X_i))^2$$

where $\hat{g}_{-i} = \sum_{j\neq i}^{n} Y_j K((X_i - X_j)/h) / \sum_{j\neq i}^{n} K((X_i - X_j)/h)$ is the leave-one-out kernel estimator of $g(\cdot)$ and the $M(X_i)$ is a trimming function which ranges between 0 and 1.

4.4.1.5 An Application

The kernel regression function applied to health income relationship is as

$$(4.8) \quad H_i = g(I_i) + e_i$$

where H_i represents the health indicators of individual i, I_i is the income of individual i, e_i is a random error term, and $g(\cdot)$ is a unspecified function.

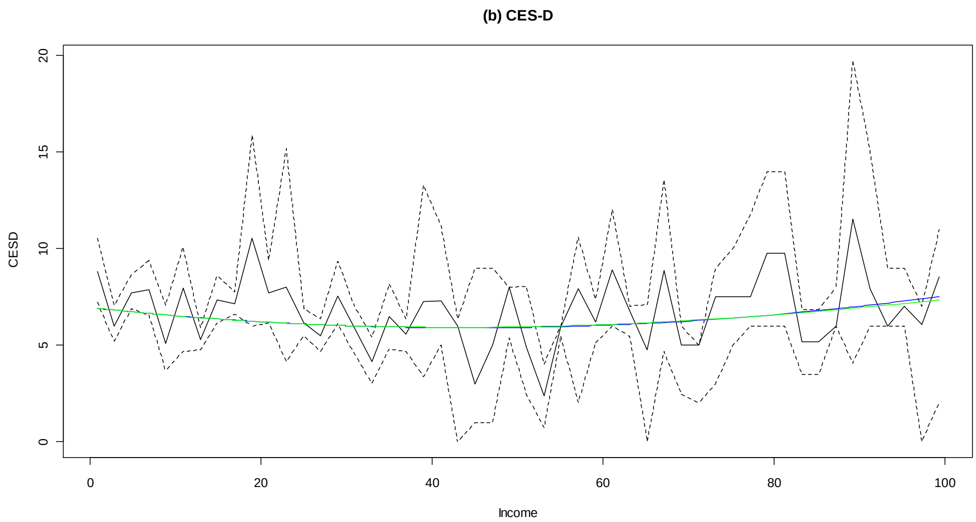
Figure 4.2 presents kernel regression, Probit regression, quadratic polynomial regression, and cubic polynomial regression for SAH, CES-D and LS, respectively. Table 4-3 shows the average derivative estimators of three indicators in different quartiles of income distribution. The meaning of average derivative estimators is similar to that of coefficients of parametric estimations to tell the changing magnitude of three indicators when income increases one unit but they are not directly comparable to the coefficients of parametric estimations. Only the average derivative estimators obtained from semi-parametric single index estimation are directly comparable (see section 4.4.4).

In the figure of SAH in Figure 4.2, differences between quadratic and cubic polynomial estimations are not obvious whereas there are big differences between two polynomial estimations and both Probit and nonparametric kernel estimations. A parabolic relationship is presented by polynomial estimations whereas a nearly linear relationship is presented by Probit estimation. The nonparametric kernel estimation presents more curvilinear relationship than two polynomial regressions. The figure of CES-D reveals no difference between two polynomial estimations but a big difference between parametric estimations and nonparametric kernel estimation is spotted. However, the figure of life satisfaction displays the difference between quadratic and cubic polynomial estimations in the top quartile of income distribution. The two polynomial estimations are also different from nonparametric kernel estimation.

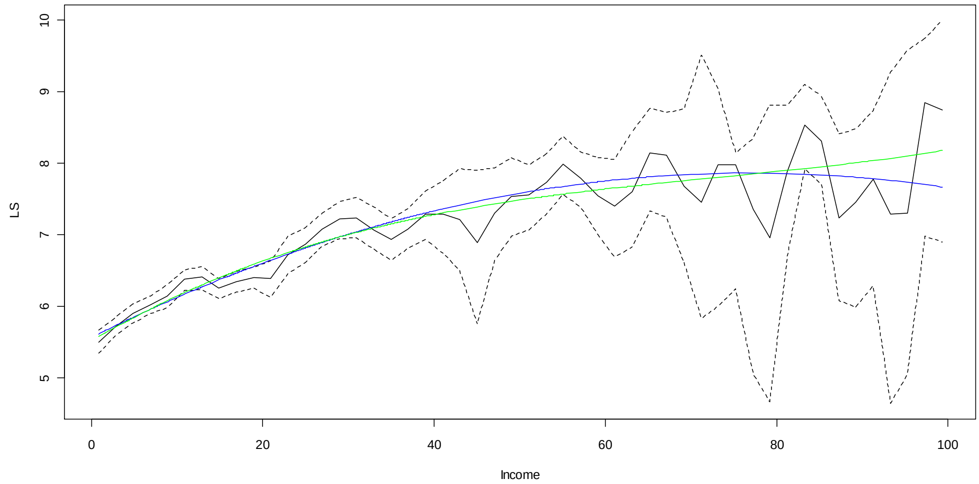
In general, the relationship between self-assessed health and income is negative whereas it is positive between life satisfaction and income. The relationship between depression and income is ambiguous. The average scale of life satisfaction goes up with the increase of income whereas the average probability of reporting good health goes down when income increases one unit.

In Figure 4.2, nonparametric estimation reveals more information of the health income relationship than parametric estimations. For instance, in the figure of self-assessed health, parametric estimations present the approximately fixed gradient of health status whereas nonparametric kernel estimation presents varied gradients of health status when income increases.

Figure 4.2 Nonparametric Kernel Estimation for SAH, CES-D, and LS



(c) Life Satisfaction



Notes: 1. The black line in the figures presents nonparametric regression.
2. The red line presents the Probit regression. The blue line presents the polynomial quadratic regression, and the green line presents the polynomial cubic regression.

The slope is of interest to researchers because it represents the variation of magnitude of the dependent variable when the explanatory variable changes by one unit. The average derivative estimators of SAH, CES-D, and LS are -0.01, 0.072, and 0.054, respectively (see Table 4-3). The average slope of the estimated line of SAH along income is negative which implies that SAH has a negative association with income in general. However, in the case of CES-D, the positive average slope implies that depression has a positive association with income generally and so does the case of LS. When income increases one unit, the average probability of reporting good self-assessed health decreases 1 percent as well as the average scale of depression and life satisfaction increases 0.072 and 0.054 point respectively.

Furthermore, the average derivative estimators (ADEs) in different quartiles of income distribution are shown in Table 4-3. The ADEs of SAH are negative in all quartiles and it approximates to zero in the bottom quartile. The absolute value of ADE is greater in the middle quartiles than that in the top quartile. The average probability of reporting good health decreases 1.2% and 0.7% in the middle and top quartiles respectively. The ADEs of CES-D are positive in the bottom and top quartiles whereas the ADE is negative in the middle quartiles and its absolute value in the middle quartiles is greater than that in the other quartiles. The average scale of CES-D increases 0.13 point and falls 0.022 point in the bottom and top quartiles respectively when income increases one unit whereas it decreases 0.778 point in the middle quartiles. In respect of LS, the signs of ADE are consistent in three income levels. It is positive and the value of ADE is 0.069, 0.667, and 0.025 respectively. The average scale of life satisfaction in the bottom, middle, and top quartiles will increase 0.069, 0.667, and 0.025 point respectively if income increases NT$1,000. The ADE in the middle quartiles is greater than that in the bottom and top quartiles.

In summary, in the middle quartiles of income distribution, the average gradients of self-assessed health, depression scale, and the scale of life satisfaction are the greatest. The depression and life satisfaction of the senior citizens have a great improvement after they escape from the bottom quartile to middle quartiles but the improvement reduces greatly after they move to the top income quartile. The possible explanation of the great improvement is that the family status and self-esteem of the senior citizens are raised after they escape from poverty and make a contribution to their family.

Table 4-3 ADE of Nonparametric Kernel Estimation in Different Income Quartiles

Health Indicators	Bottom 25%	25% - 75%	Upper 25%	Overall
SAH	-1.06e-13	-0.012	-0.007	-0.01
CES-D	0.13	-0.778	-0.022	0.072
LS	0.069	0.667	0.025	0.054

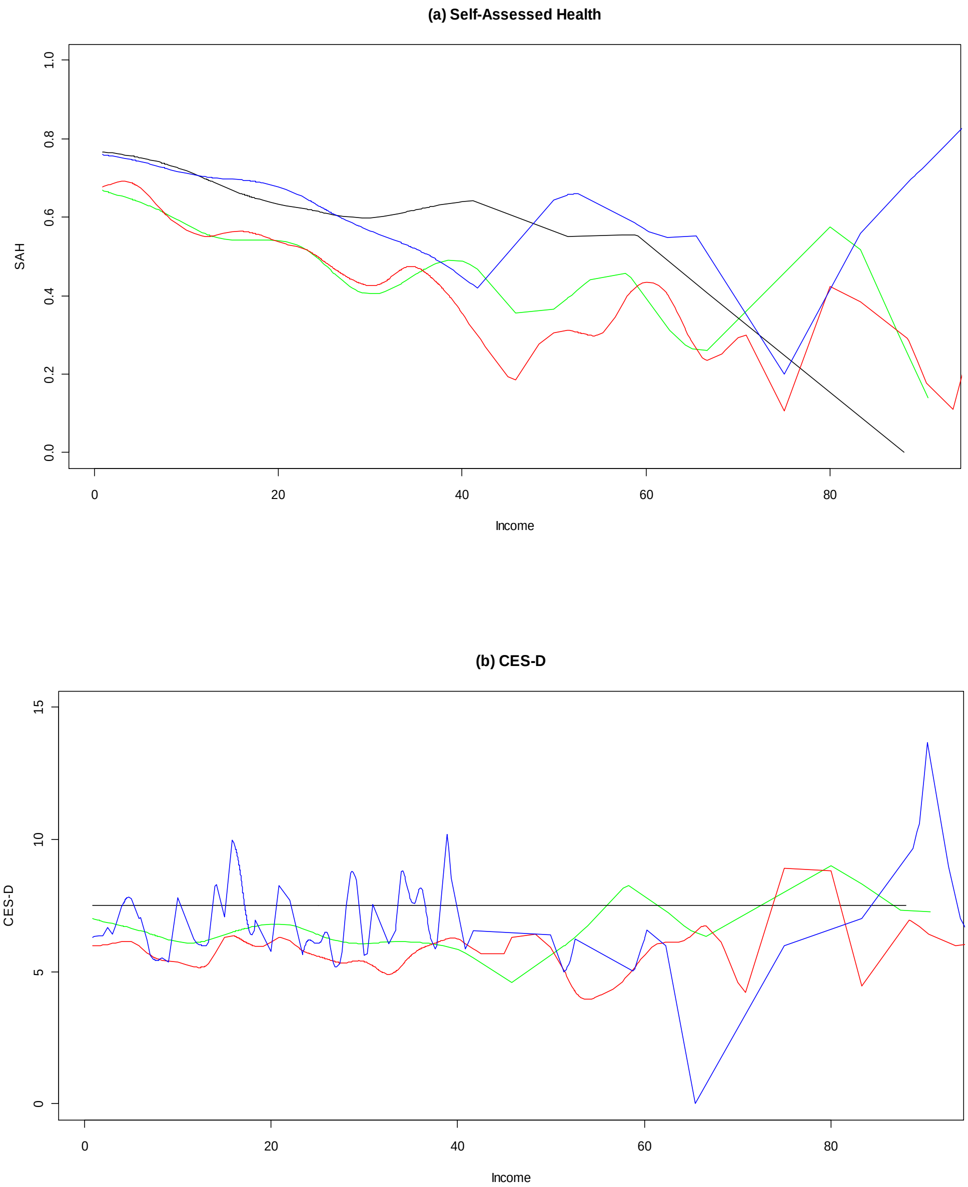
Note: Q1 represents the income below 25% of income ranking (approximate to NT$4,269) and Q3 represents the income above 75% of income ranking (approximate to NT$17,407).

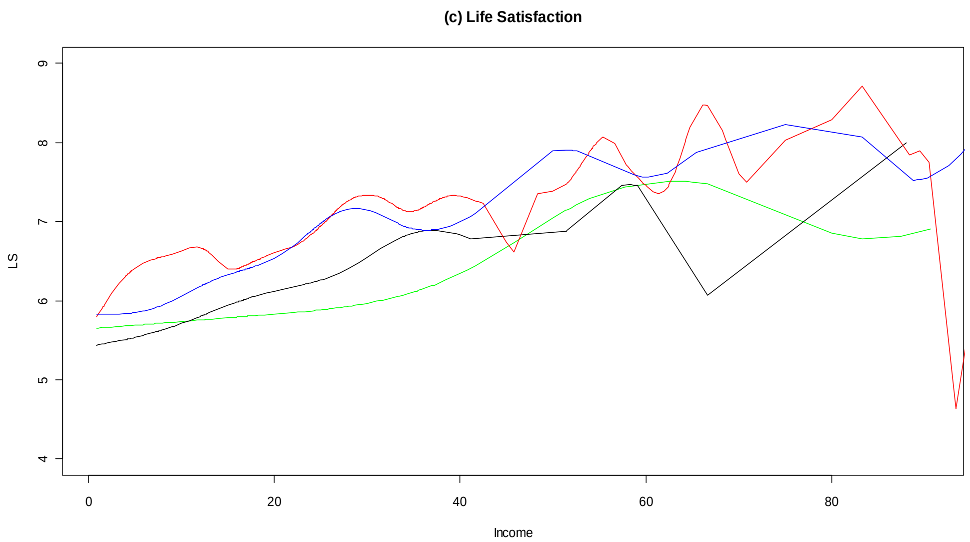
The pattern of relationship between income and health indicators for the four groups partitioned by gender and marital status is shown in Figure 4.3 and the average derivative estimators are displayed in Table 4-4. Figure 4.3 reveals that sex and marital status appear to be of significance to SAH, CES-D, and LF. In the figure of self-assessed health, the relationship between self-assessed health and income in four groups appears negative in general and the relationship of the single female group is relatively linear. Males are less likely to report good health than females and married males have less probability to report good health than single males after marriage is controlled. Above the approximated income level of NT$58,000, the relationship in the single female group is negatively linear. It means that the likelihood of reporting good health in the single female group reduce constantly when income increases.

In the figure of CES-D, the relationship between CES-D and income is ambiguous in general but it is distinct that the female groups report more depression than the male groups below the approximated NT$50,000. Single females report more depression than married females and it is also the case in males groups. Above that income level, in general, the order of reporting high depression is single females, single males, married males, and married females. However, the single female group reports more depression than other groups whether at high or low income levels and its relationship is linear and nearly horizontal. One interesting circumstance in this figure is gender seems to be a determinant of depression when income is below NT$50,000 whereas marriage is a likely determinant when income is above NT$50,000. In the figure of life satisfaction, the relationship between life satisfaction and income is positive in general. The married groups show more life satisfaction than the single groups.

In summary, after controlling for gender, married people report more life satisfaction and less depression than single people at the same income level. After controlling for marital status, males report a lower probability of reporting good health status and less depression than females.

Figure 4.3 Nonparametric Estimation by Sex and Martial Status





Note: The blue and black lines represent married and single females, respectively. The red and green lines represent married and single males, respectively.

In Table 4-4, the average gradient in the estimation of SAH is negative for the 4 groups. The male groups show a larger average gradient than the female groups. It implies that the probability for males to report good self-assessed health decreases more than females when income increases one unit. When income increases one unit, married males will be 0.8% less likely to report good health, which is on top of the list among four groups. The following order is single males and both female groups as well as the reducing probabilities are 0.65% and 0.5%, respectively.

In the estimation of CES-D, CES-D has a negative relationship with income in four groups although the average derivative of single females approximates to zero. The married groups have a greater average gradient than the single groups and married females have a larger average gradient than married males. It means that married groups reduce more depression than single groups when income increases one unit. Meanwhile, married females reduce more depression than married males by more than six times when income increases one unit. However, the depression level of the single female group almost does not change with the change of income.

Life satisfaction shows a positive relationship with income in four groups. When income increases one unit, the life satisfaction of the married groups increases more than that of the single groups when gender is controlled and the life satisfaction of the married male group increases more than the married female group.

Table 4-4 ADE of Nonparametric Regression

Group	SAH	CES-D	LS
Married Female	-0.005	-0.264	0.032
Single Female	-0.005	-1.53e-15	0.03
Married Male	-0.008	-0.042	0.049
Single Male	-0.007	-0.031	0.011

4.4.2 Semi-parametric Partially Linear Regression

Semi-parametric regression combines the properties of parametric and nonparametric estimations. It includes some parametric components and leaves some components unspecified in the regression. The parametric components are the control characters for obtaining a more precise association between the dependent variable and its covariates of interest. In the case of health and income, the main concern is the association between income and health. Although the association is presented when estimating using nonparametric regression, the individual’s other characteristics are not controlled in these estimations apart from the fact that the sample is partitioned according to the individual’s characteristics before estimating. The advantage of semi-parametric estimation is it can control an individual’s characteristics in the estimation and need not partition sample into groups before estimation.

4.4.2.1 Partially Linear model

A semi-parametric partially linear model with *p* dimensions is given by

$$(4.9) \quad Y_i = X_i^{'}\beta + g(Z_i) + u_i, \quad i = 1, \cdots, n$$

where X_i is a $p \times 1$ vector, β is a $p \times 1$ vector of unknown parameters, and $Z_i \in \Re^q$. The functional form of $g(\cdot)$ is unspecified. This model combines the parametric vector, β, and the nonparametric part, $g(\cdot)$. Meanwhile, the covariate vector, X, has linear form in the model. In the example of health and income association, Z_i is absolute income amount and the X vector is the other individual's socioeconomic status such as education and occupation, etc. The semi-parametric model can make health income relationship clearer after controlling for an individual's socioeconomic status.

The first step in estimating a semi-parametric partially linear model is to estimate the unknown parametric vector, β. After obtaining the parametric vector, one can replace β with $\hat{\beta}$ to obtain the estimate of $g(\cdot)$, $\hat{g}(\cdot)$. In the semi-parametric partially linear model, the constant term must be excluded from the equation for reasons of identification.

4.4.2.2 The estimates of parametric part

Robinson (1988) proposes a method of estimating the coefficient β. Transform Eq. (4.9) by taking the conditional expectation and then subtracting Eq. (4.10) from Eq. (4.9).

$$(4.10) \quad E(Y_i \mid Z_i) = E(X_i \mid Z_i)'\beta + g(Z_i)$$

$$(4.11) \quad Y_i - E(Y_i \mid Z_i) = (X_i - E(X_i \mid Z_i))'\beta + u_i$$

In order to implement the estimation, the expected values in Eq. (4.11) are replaced by their nonparametric estimates denoted by $\hat{Y}_i$ and $\hat{X}_i$, respectively. Meanwhile, the density-weighted approach is used to avoid the problem caused by a random denominator $\hat{f}(Z_i)$ in the kernel estimator. Rewrite Eq. (4.11) and show in Eq. (4.12)

$$(4.12)\quad (Y_i - \hat{Y}_i)\hat{f}(Z_i) = (X_i - \hat{X}_i)'\hat{f}(Z_i)\beta + u_i\hat{f}(Z_i)$$

where

$$(4.13)\quad \hat{Y}_i \equiv \hat{E}(Y_i \mid Z_i) \overset{def}{=} n^{-1}\sum_{j=1}^{n} Y_j K_h(Z_i, Z_j)/\hat{f}(Z_i)$$

$$(4.14)\quad \hat{X}_i \equiv \hat{E}(X_i \mid Z_i) \overset{def}{=} n^{-1}\sum_{j=1}^{n} Y_j K_h(Z_i, Z_j)/\hat{f}(Z_i)$$

and

$$(4.15)\quad \hat{f}(Z_i) = n^{-1}\sum_{j=1}^{n} K_h(Z_i, Z_j)$$

where $K_h(Z_i, Z_j) = \prod_{s=1}^{q} h_s^{-1} k(\frac{Z_{is} - Z_{js}}{h_s})$.

Regress $(Y_i - \hat{Y}_i)\hat{f}(Z_i)$ on $(X_i - \hat{X}_i)'\hat{f}(Z_i)$ by least squares method and finally β is obtained.

4.4.3 The estimates of nonparametric part

$g(\cdot)$ can be obtained from Eq. (4.10) and it is equal to $E(Y_i - X_i'\beta \mid Z_i)$. After obtaining the $\sqrt{n}$-consistent estimator of β, $\hat{\beta}$, a consistent estimator of $g(\cdot)$ is given by

$$(4.16)\quad \hat{g}(Z_i) = \frac{\sum_{j=1, j\neq i}^{n}(Y_i - X_j'\hat{\beta})K_h(Z_i, Z_j)}{\sum_{j=1, j\neq i}^{n} K_h(Z_i, Z_j)}$$

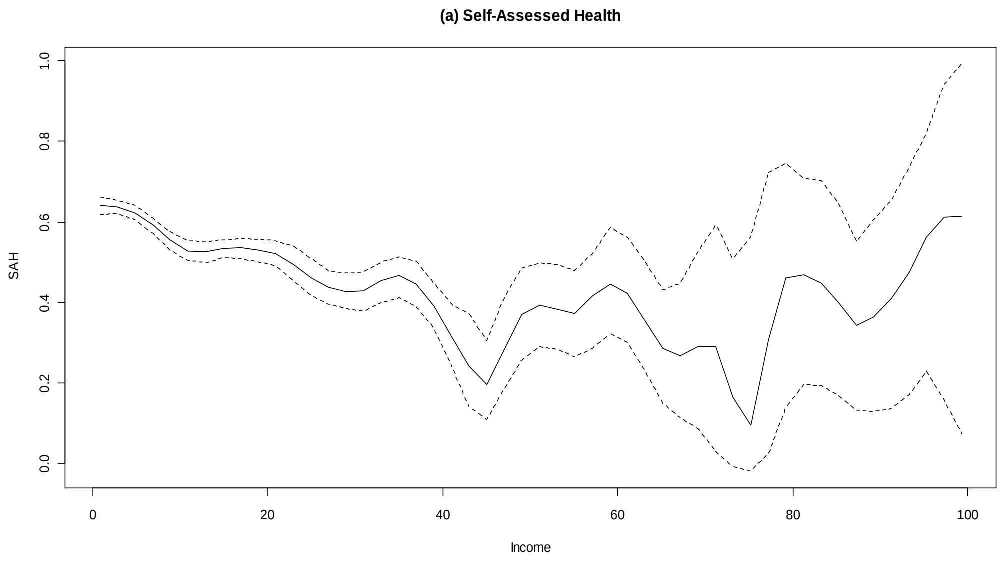
The nonnegative second order kernel is used to estimate $\hat{g}(Z_i)$ and the bandwidth h is selected by the method of least square cross-validation.

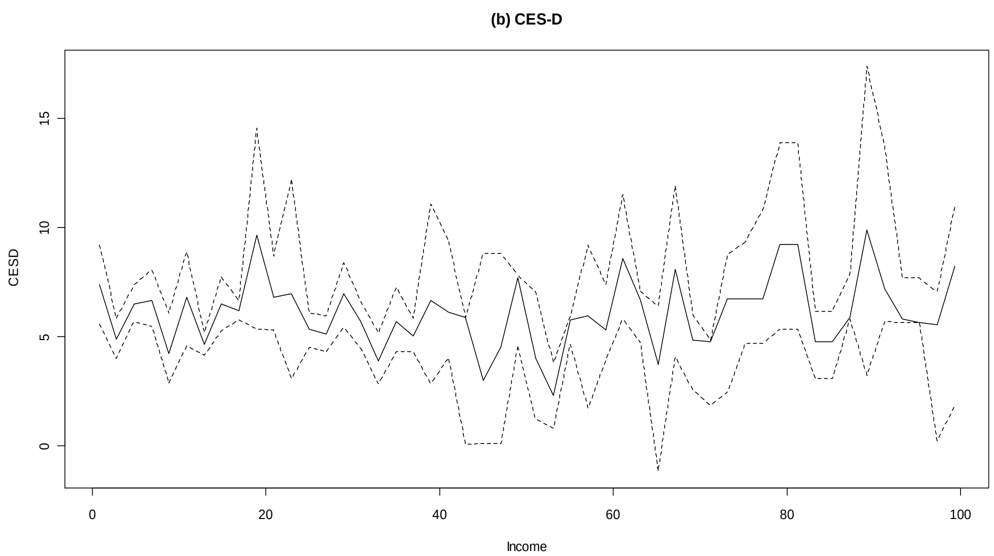
4.4.3.1 An Application

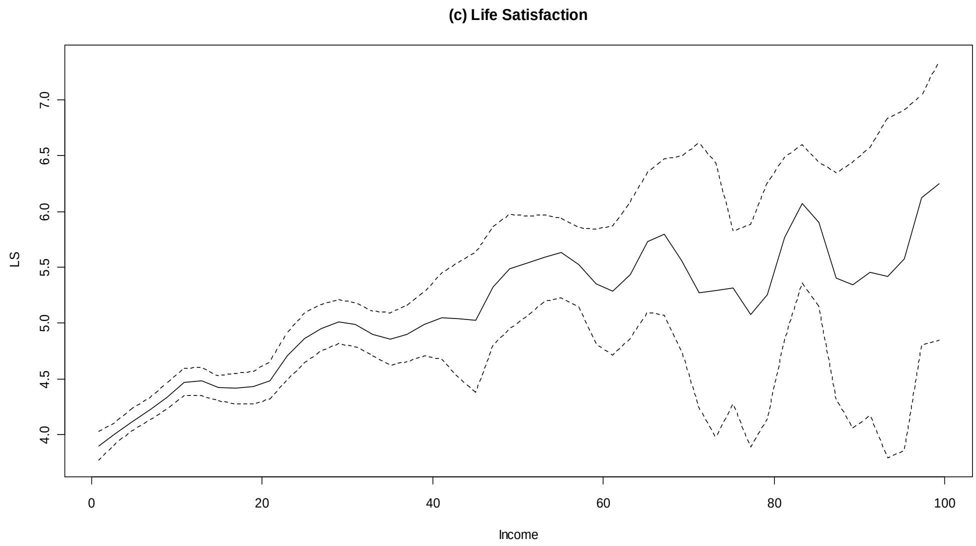
The demographical characteristics of age, sex, education, and marital status are controlled in the regression when estimating the unknown functional form of income and the result is presented in Figure 4.4 and Table 4-5. The patterns of three indicators in Figure 4.4 are similar to those in Figure 4.2 but they move down slightly.

Table 4-5 displays the ADEs in different income quartiles after controlling the demographical variables in the estimation. Comparing Table 4-5 with Table 4-3, the signs of ADE in Table 4-5 are consistent with those in Table 4-3 but the absolute values of ADE become smaller apart from the ADE of overall CES-D and the ADE of CES-D in the bottom quartile. In the bottom quartile of income distribution the average scale of depression becomes greater after controlling demographical variables, which causes the bigger ADE of overall CES-D. The average scale of depression increases 2.829 points in bottom quartile and 0.311 point overall when income increases one unit.

Figure 4.4 Semi-parametric Partially Linear Estimation for SAH, CES-D, and LS







Notes: 1. The line in the figure presents semi-parametric regression.
2. The points in the figures present the polynomial quadratic regression.

Table 4-5 ADE of Semi-parametric Partially Linear Estimation in Different Income Quantiles

Health Indicators	Bottom 25%	25% - 75%	Upper 25%	Overall
SAH	-2.76e-14	-0.01	-0.001	-0.007
CES-D	2.829	-0.537	-0.012	0.311
LS	0.061	0.078	0.02	0.031

Note: Q1 represents the income below 25% of income ranking (approximate to NT$4,269) and Q3 represents the income above 75% of income ranking (approximate to NT$17,407).

Table 4-6 shows the ADEs of semi-parametric partially linear estimation in four groups partitioned by marital status and gender factor. Comparing Table 4-6 with Table 4-4, the absolute values of ADE are smaller than those in Table 4-4 apart from the case of CES-D in the single male group. The ADE of the single male group in the CES-D estimation is the same as that in Table 4-4. The signs of ADE are the same as those in Table 4-4 apart from the case of CES-D in the single female group where it becomes positive but it maintains a very small value.

In summary, after controlling age and education factors in the estimations of four groups, the results are similar to those before controlling the demographical variables. The average probability of the male groups to report good health decreases more than the female groups when income increases one unit and the married groups increase more life satisfaction than the single groups. In respect of CES-D, depression level in married females decreases the most among four groups when income increases one unit.

Table 4-6 ADE of Semi-parametric Partially Linear Regression for Four Groups

Group	SAH	CES-D	LS
Married Female	-0.003	-0.19	0.022
Single Female	-0.003	0.001	0.015
Married Male	-0.006	-0.027	0.037
Single Male	-0.006	-0.031	0.009

4.4.4 Semi-parametric Single index Regression

The ADEs estimated beforehand are not directly comparable to the coefficients obtained from the parametric estimation. Thus, the semi-parametric single index model is introduced because the average derivative estimators produced by this model are directly comparable to the coefficients of parametric estimations (Blundell and Duncan, 1998). The form of the semi-parametric single index model (SIM) is

$$(4.17) \quad Y = g(X'\beta) + u$$

where Y is the dependent variable, X is a vector of q explanatory variables, β is the $q \times 1$ vector with unknown parameters, and u is the error satisfying $E(u|X) = 0$. The function form of $g(\cdot)$ is still left unknown. Many studies concern the estimation of β, for example, Hardle and Stoker (1989), Powell et al. (1989), Rilstone (1991), Ichimura (1993), and Klein and Spady (1993). Once the β is obtained, the $g(\cdot)$ can be estimated.

4.4.4.1 An Application

The purpose of implementing SIM is to compare the estimates of coefficients under two alternative assumptions: functional form known versus unknown. The estimation used in the case of CES-D and LS is proposed by Ichimura (1993) and the estimation used in the case of SAH is proposed by Klein and Spady (1993). The coefficients in three cases are obtained by estimating the average derivative estimators and the results are shown in Table 4-77. The signs of average derivative estimators are consistent with those obtained by parametric estimations whereas the absolute values of the average derivative estimator for three indicators are smaller than those in Probit and OLS apart from the case of CES-D. The income square in the case of CES-D is not significant at 5% level, which implies that the relationship between CES-D and income is not a quadratic form but it cannot mean that the linear form is correct. Even if the square term in the LS estimation is significant at 1% level, it cannot either say the quadratic form between life satisfaction and income is correct. The model specification test will answer these questions.

Table 4-7 Probit, OLS, and SIM for SAH,CES-D, and LS

			SAH		
	Probit			SIM	
Var.	Coef.	St. Error	Var.	ADE.	St. Error†
Income	-0.01***	0.021	Income	-0.003	0.0002
			CES-D		
	OLS			SIM	
Var.	Coef.	St. Error	Var.	ADE.	St. Error†
Income	0.002	0.981	Income	0.006	0.0006
Squ. Income	0.0001	0.054	-	-	-
			LS		
	OLS			SIM	
Var.	Coef.	St. Error	Var.	ADE.	St. Error†
Income	0.038***	0.525	Income	0.032	0.002
Squ. Income	-0.0002***	0.029	-	-	-

Note: 1. *** 1% significant level; ** 5% significant level; * 10% significant level
2. † represents the bootstrapped standard error.

4.5 Model Specification Test

SAH is a binary variable so the Logit or Probit model is usually used in this estimation. Either the Logit or Probit model constitutes the nonlinear estimation with specified functional form. Thus, the regressors are presumed to have a nonlinear relationship with SAH. With respect to CES-D and LS, the two variables can be regarded as the continuous variables though the ranges of their scale are in 0-30 and 0-10, respectively. OLS is usually the first try to estimate the continuous dependent variables. The square term is usually a regressor if one expects the explanatory variable to have a nonlinear relationship with the dependent variable. Thus, the square term of income is a regressor in the regressions of CES-D and LS. Table 4-7 shows that income has a nonlinear relationship with LS according to the significance of square term of income, but an ambiguous relationship with CES-D because the square term is not significant, which does not mean the cubic term or the higher-order terms are not significant.

Is the quadratic parametric form a correct specification to interpret the health income relationship? The model specification tests will answer this question. In the parametric model specification test, it requires the user to specify a set of parametric alternatives to compare with null specification and the null hypothesis will be rejected if the data generating process indeed follows the alternative models. However, the parametric model specification test will be an inconsistent test because it lacks power in certain directions if there exist the alterative models which cannot be detected (Li and Racine, 2007, p.351). Nonparametric methods can overcome this problem and conduct a consistent test.

The test implemented here is proposed by Li and Racine (2007). They test the correct specification of a parametric model based on the value of integrated square difference between the parametric model and the nonparametric model. The null hypotheses here are $\mathrm{E}(H|x) = \alpha + \beta_1 x$, $\mathrm{E}(H|x) = \alpha + \beta_1 x + \beta_2 x^2$, and $\mathrm{E}(H|x) =$

$\alpha + \beta_1 x + \beta_2 x^2 + \beta_3 x^3$, where H is health outcome and x is income. If the null hypotheses are rejected respectively, it means the parametric linear, quadratic, and cubic forms of income are not a correct specification to interpret health income relationship. However, this test cannot be implemented if the dependent variable is a binary outcome. It is only applicable to continuous dependent variables. This test rejects the null models of CES-D and LS at 1% significant level.[21] It means that the parametric forms mentioned above are a misspecification when depression, life satisfaction, and income variables are taken into account in the analysis.

4.6 Conclusion

The relationship between income and health in elderly group (those aged between 60 and 80) is of primary interest in this chapter. The analysis data are micro-level data from the Survey of Health and Living Status of the Elderly. In the previous literature, many studies use the square term of income or even higher-order terms as the regressors to present the nonlinear relationship between health and income. In view of the potential problem of misspecification, the model specification test and nonparametric strategy are implemented in the present analysis. Nonparametric kernel and semi-parametric partially linear estimations all provide the evidence that there is a nonlinear relationship between three indicators and income. Meanwhile, these estimations also reveal the circumstance of health inequality related to income in detail. The model specification test rejects the parametric linear, quadratic, and cubic forms are not a correct specification. It makes the distinction between nonparametric estimation and three parametric forms when income is concerned.

[21] In the case of CES-D the test statistics of ‘Jn’ of parametric linear form, quadratic form, and cubic form are 33.138, 31.838, and 31.762, respectively, and P-values are less than 2.22e-16. In the case of LS the test statistics, ‘Jn’, are 4.323, 2.611, and 2.581 and each P-vale of ‘Jn’ is less than 2.22e-16.

Self-assessed health has a negative relationship with income and this is different from our prior expectation. The relationship between life satisfaction and income is positive, which is the same as expectation. However, the relationship between depression and income is ambiguous. One plausible reason is that age might replace income to become an influential determinant of self-assessed health for the population aged between 60 and 80 years. According to average derivative estimators, the average scale of depression reduces in the middle quartiles (25%-75%) whereas in the other quartiles it increases when income increases. The average scale of life satisfaction increases substantially with the increase of income in the middle quartiles.

After the sample is partitioned into several subgroups by using gender and marital status, single females have an approximately horizontal relationship between depression and income and a relatively linear relationship between self-assessed health and income whereas married males and females have a more curvilinear relationship in the cases of self-assessed health and life satisfaction. Thus, the self-assessed health status and life satisfaction for married people is more sensitive to income than for single people.

The curvilinear relationship implies that health status is more sensitive to income change and, further, it is able to reflect income-related health inequality. The social support or the social benefits for specified people at different income levels or in different groups would have more effects on reducing the depression and improving life satisfaction of the elderly. With respect to self-assessed health, the effect of the social support and the social benefits on self-assessed health is uncertain according to above empirical results which show that the negative health income relationship. If the social support and the social benefits are given, the probability for the elderly in low income level to report good health will decrease due to the increase of income so that the average self-assessed health will drop. One of the possible methods to improve average self-assessed health is taking money from rich people to provide and support the health relevant public goods.

Chapter 5. Handling the endogeneity of income to health using a field experiment in Taiwan

5.1 Introduction

This chapter uses quasi-experimental methods to examine the absolute income hypothesis. The absolute income and the relative income hypotheses are the mainstream of the discussion. Even if the conclusions are mixed, income is still a crucial factor for health, whether viewed in physical or psychological terms. From a physical perspective, for example, money can buy more nutritious food and better quality medical treatment whereas from a psychological perspective, for example, money offers the security and obviates financial stress. In the discussion of this topic, the endogeneity is another story apart from the health social gradient. Individuals with low income may have worse health either from physical causes or from a psychological perspective. Conversely, their low incomes may result from their poor health. Because of this argument, an alternative means of estimating the health income association is to find exogenous time variation in income, such as that provided by policy changes.

In the endogenous scenario, econometric methods usually utilise instrumental variable estimation to deal with the income effect on health (Etter, 1996; Meer et al., 2003). Another way to identify the effect is the quasi-experimental method (Gardner and Oswald, 2007). This chapter uses two quasi-experimental methods, difference-in-differences (DiD) and regression discontinuity (RD), to evaluate the policy effect of the Senior Farmer Welfare Benefit Interim Regulation (SFWBIR) on health. Those farmers who are 65 years of age and have been members of Farmer Health Insurance (FHI) for at least 6 months are eligible to claim a specific amount benefit until they die.

The Farmer Health Insurance is the only occupational insurance that does not contain a retirement pension. The senior farmers are unable to receive any pension to secure their retirement whereas the other workers claim their retirement pension from their particular occupational insurance[22]. In 1995, the government implemented the Senior Farmer Welfare Benefit Interim Regulation to compensate for absence of retirement pension in Farmer Health Insurance. This is a pure cash injection policy so it is a good instrument for evaluating the absolute income effect on health and happiness. Indirectly, it is a test for the absolute income hypothesis.

The validity of a difference-in-differences strategy depends crucially on the comparability of control and treatment groups - whether the experiences of the control group accurately represents how the treatment group would have fared in the absence of legal intervention and on the common time trend (the time trends for two groups are parallel) which captures the wider changes in society which are unrelated to the particular policy we are interested in evaluating. However, regression discontinuity can avoid these defects because of its property of randomization around the cut-off point and its feasibility with one wave data after policy intervention. Hence, regression-discontinuity is used as an auxiliary to compare with the difference-in-differences estimate.

This chapter is organised as followings. Section 2 reviews the previous literature. Section 3 introduces the social welfare policies of the senior citizens in Taiwan and section 4 discusses the different-in-differences model and RD design. Section 5 introduces the data set from the Survey of Health and Living Status of the Elderly (SHLE) used in this chapter. Section 6 describes the empirical strategies. Section 7 shows the results of empirical results. Finally, section 8 is conclusion.

[22] Before the implementation of SFWBIR, councils in a few counties had provided similar benefits for their senior farmers, especially in agricultural counties. The amount differs from county to county. However, the proportion of those claiming the benefit was not high before 1995.

5.2 Previous Research

The vast majority of papers discuss the health income hypotheses based on the assumption of health social gradient – a negative relationship between health indicator and socioeconomic status. In this framework the health status at the left hand side of the equation and the other factors, such as demography and income, are at the other side.

Smith (1999) describes the patterns of association between wealth and health from two data sets, HRS and the Asset and Health Dynamics of the Oldest Old Survey. He finds the wealth is affected by health not only through the productivity of labour but also through other aspects, such as health anticipation and health insurance. He also makes the same description in health social gradient. However, these patterns cannot explain whether there is a causal link in the association between health and wealth or income if the researchers only take one of the associations into consideration. Hence, identification is needed in the discussion that one variable may have a structure effect on another variable.

There are some methods to identify the causal relationship between health and income, including experiment, natural experiment, instrumental variables and econometric identification. Meer et al. (2003) use the data drawn from four waves, 1984, 1989, 1994 and 1999, of a Panel Study of Income Dynamics and find an instrument, the inheritance, for the change in wealth to identify the association between health and wealth. Their results show that wealth has positive and statistically significant effects on health but its magnitude is very small. After implementing IV estimate they find that the results are approximately the same but the coefficient of wealth becomes nonsignificant. Finally, they conclude that short term change in wealth does not affect health status. The similar estimate has been done by Ettner

(1996). The author uses the combined data from National Survey of Families and Households, the Survey of Income and Program Participation and NHIS to estimate the structural impact of income on several measures of health. She compares the results of OLS with IV estimates and finds both of the estimates show that an increase in income significantly improves mental and physical health but it also increases the prevalence of alcohol consumption.

An alternative method is as Adams et al. (2003). The authors test for the absence of effect of socioeconomic status on innovations in health. They hypothesize there is no causality. If this hypothesis is accepted, it implies that there is no causal link and no persistent hidden factors moulding initial status and subsequent innovations. They find that the significantly positive association between health and socioeconomic status at the initial stage; however, the change of wealth has no significant effects on innovations of health. Hence, they conclude that there is no causal link from wealth to mortality or the sudden onset of health conditions.

Gardner and Oswald (2007) ask a question of whether money makes people happy. They adopt the data between 1996 and 2003 from BHPS and use lottery wins as a natural experiment to investigate the relationship between innovations of money and health. The sample is partitioned into two groups, one with no wins and the other with small wins and their results show that the individuals with small wins go on to eventually exhibit better mental health. After two years, the average GHQ score of winners improves by 1.4 points.

In summary, the relationship between income or wealth and health is still inconsistent whether considering health social gradient or the causal link between health and income. In this chapter, a policy of social welfare for senior farmers is used to identify the causal link. Before the identification, the general situation of elderly welfare in Taiwan is introduced in next section.

5.3 Background and Investigating Motivation

5.3.1 Social schemes

Social schemes are a crucial component of the social security system. The purpose of such social schemes is not only to secure the economic wellbeing of senior citizens but also to lighten somewhat the burden of the younger generation in the family. To date the social schemes in Taiwan include Labour Insurance (LI), Government Employee Insurance (GEI), Farmer Health Insurance, National Pension Scheme (NPS), the Military Insurance (MI) and National Health Insurance (NHI). Each of these schemes is supervised by a different government department. Apart from National Pension Scheme and National Health Insurance, these compulsory schemes are specific to particular occupations. National Health Insurance applies to all Taiwanese citizens regardless of age and occupation whereas National Pension Scheme applies to all adults who are over 25 and under 65 years of age and are not covered by any one of the compulsory occupational schemes.

Among these schemes, Farmer Health Insurance and National Health Insurance are health insurances. Hence they mainly cover medical utilization instead of offering retirement pension. However, Farmer Health Insurance is the only social scheme specific to a particular occupation without the retirement pension comparing with Labour Insurance, Government Employee Insurance and Military Insurance. Hence the government implemented the Senior Farmer Welfare Benefit Interim Regulation in 1995 to redress the lack of the retirement pension in the Farmer Health Insurance.

Although the occupational schemes cover most Taiwanese citizens, there are still 4.7 million people between 25-65 years of age who are not covered. In order to cover this population, the government implemented National Pension Scheme in 2008. It is a compulsory scheme for Taiwanese citizens at 25-65 years of age and not covered by any occupational scheme. Before the implementation of the National Pension Scheme, the government considered the people not covered under any occupational schemes have no retirement pension so the Senior Welfare Benefit Interim Regulation (SWBIR) was implemented in 2003. It benefits the senior citizens aforementioned and the other senior citizens meeting the criteria even if they are covered by a particular occupational insurance. However, this regulation is a transitional stage of the National Pension Scheme. It was abolished after the National Pension Scheme was implemented.

Apart from the social benefits cited above, the government implements other social welfare benefits to complement the social schemes in order to make the social security system more comprehensive.

5.3.2 The elderly welfare in Taiwan

During the 1970s and 1980s, the Taiwanese people brought about a well-documented economic miracle within East Asia and the whole society moved away from poverty and into an affluent stage. At the same time, thanks to the progress of medical treatment, the life span of Taiwanese people was prolonged.

Table 5-1 Statistics for population and life span

Year	Total population	The elderly population			Prop. of elderly citizens	Life expectancy	
		Sum	Male	Female		Male	Female
1995	21357431	1631054	892767	738287	7.64%	71.85	77.74
1996	21525433	1691608	923139	768469	7.86%	71.89	77.77
1997	21742815	1752056	949880	802176	8.06%	71.93	77.81
1998	21928591	1810231	973455	836776	8.26%	72.20	77.96
1999	22092387	1865472	992852	872620	8.44%	72.46	78.12
2000	22276672	1921308	1011023	910285	8.62%	72.67	78.44
2001	22405568	1973357	1026591	946766	8.81%	72.87	78.75
2002	22520776	2031300	1045154	986146	9.02%	73.22	78.94
2003	22604550	2087734	1063368	1024366	9.24%	73.40	79.31
2004	22689122	2150475	1083496	1066979	9.48%	73.47	79.70
2005	22770383	2216804	1105422	1111382	9.74%	74.50	80.80

Source: Statistics of the Ministry of the Interior

Table 5-1 shows that the life expectancy for males and females was 74.5 and 80.8 years respectively in 2005. It increases 3 years for both genders over a decade though the gap between two genders maintains at about 5 years.

According to the statistics of the Taiwanese Ministry of the Interior, in 1993 1,490,801 people were 65 years old and over, approximately 7.1 percent of the population. It had achieved the definition of an aging population according to the World Health Organization[23]. In 2001, the proportion went up to 8.81 percent and, in 2003, the proportion increased to 9.24 percent. By 2007, it was 10.04 percent. With the onset of an aging society, elderly welfare policies gradually become an issue. The first Elderly Welfare Act (EWA) was enacted in 1980 and amended in 1997. After the 1997 amendment, the Elderly Welfare Act covered almost all the needs of senior citizens, such as benefits, pension, accommodation, and other protection. The guarantee of economic security is a crucial aim in this Act. Economic security comprises three regulations: first, financial benefits for senior citizens in households with low income; second, financial benefits for senior citizens in middle income households; third, additional care benefits for senior citizens in households with low and middle income. The amount of benefits depends on the economic status of their households. For example, senior citizens can receive NT$6,000 (New Taiwan Dollar)[24] if the income per head in the household is lower than 1.5 times of the announced lowest living expense. The amount is NT$3,000 if the income per head in the household is higher than 1.5 times but less than 2.5 times of the government's announced lowest living expense. The announced lowest living expense is different in Taiwan province, Taipei city, Kaohsiung city, Kinmen county and Lienchiang county because of urbanization. Table 5-2 shows the lowest living expense in each area.

[23]The criterion of an aging society for WHO is tone where he proportion of the elderly population is more that 7% for the country as a whole.

[24] The average current exchange rate to U.S. Dollars in 1995 was US$1 exchanged NT$27.27. NT$3000 is approximately US$110. This amount was approximate to half of the lowest living expenses in Taiwan province in 1996.

Overall, the purpose is to protect those senior citizens whose economic position occurs to the left extreme of income distribution to suffer from the risk of poverty.

In 1995 the government enacted a benefit regulation for the senior farmer citizens called the Senior Farmer Welfare Benefit Interim Regulation (SFWBIR). The definition of a senior farmer was an individual who was aged 65 years or older and had participated in the Farmer Health Insurance[25] for at least 6 months. The people who were defined as senior farmers and did not claim the old-age pension from any other social schemes or other benefits from government were eligible to claim the senior farmer welfare benefit. In 1998 the first amendment was made. First, the definition of a senior farmer included the fishermen who had been the first categorical member of fishermen union and had participated in the labour insurance scheme for 6 months before 13th November 1998 without interruption. Meanwhile, they had to start to claim the retirement pension from the Labour Insurance before 13th November 1998. The fishermen meeting the above criteria are eligible to claim the benefit. Second, a senior farmer who has claimed the old-age pension from any other social schemes or other benefits from government can choose the benefit of SFWBIR or the original benefit. Third, those senior citizens who have claimed the pension from other social schemes but participated in Farmer Health Insurance or the membership of the first category of fishermen unit which is covered by Labour Insurance after the amendment are ineligible to claim SFWBIR benefit.

To date, the SEWBIR benefit increases from NT$3,000 per month in 1995 to NT$4,000 per month in 2004 and, further, to NT$6,000 per month in 2007.

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[25] There are five criteria to participate in famer health insurance: 1. Age of participants is 15 and older; 2. The participants have to perform agricultural work for 90 days or more every year; 3. No other full time jobs; 4. If the participants are landowners or land tenants, they have to work in agriculture consecutively for one year; 5. The output of products of agriculture, forestry, and animal husbandry achieves NT$30,600 per head in one year or the input of equipment achieves 20,400 per head in one year; 6. No reception of other benefits or pension from social insurance.

Table 5-2 Lowest living expense in each area

Area / Year	Taiwan province	Taipei city	Kao-hsiung city	Kin-men county	Lien-chiang county	Exchange Rate USD/NTD	Exchange Rate GBP/USD	GDP per capita (USD)
1985	1,950	2,100	2,000	-------	-------	39.85	1.29	-------
1986	2,000	2,250	2,000	-------	-------	37.82	1.46	-------
1987	2,100	2,250	2,100	-------	-------	31.77	1.63	-------
1988	2,200	2,350	2,200	-------	-------	28.59	1.78	-------
1989	2,400	3,000	2,400	-------	-------	26.4	1.63	7,520
1990	2,700	3,588	2,700	-------	-------	26.89	1.78	8,086
1991	3,200	4,050	3,200	-------	-------	26.80	1.76	8,973
1992	3,800	4,465	3,800	2,400	2,400	25.16	1.76	10,572
1993	4,300	4,920	4,300	3,000	3,000	26.38	1.5	11,028
1994	4,650	5,730	4,650	4,000	3,500	26.45	1.53	11,932
1995	5,000	6,290	5,000	4,400	4,000	26.47	1.57	12,865
1996	5,400	6,640	5,400	4,400	4,400	27.45	1.56	13,376
1997	6,000	6,720	6,000	4,700	4,700	28.66	1.63	13,739
1998	6,700	7,750	6,700	5,800	5,800	33.44	1.65	12,546
1999	7,110	11,443	8,828	5,800	5,800	32.26	1.61	13,534
2000	7,598	11,625	9,152	5,900	5,900	31.22	1.51	14,641
2001	8,276	12,977	9,814	5,900	5,900	33.8	1.44	13,107
2002	8,433	13,288	9,559	6,000	6,000	34.57	1.5	13,369
2003	8,426	13,313	9,712	6,000	6,000	34.41	1.63	13,737
2004	8,529	13,797	9,102	6,300	6,300	33.42	1.83	14,985
2005	8,770	13,562	9,711	6,300	6,300	32.16	1.82	16,022

Source: 1. Directorate-General of Budget, Accounting and Statistics, Executive Yuan National Statistics, Taiwan. 2. Central Bank of Taiwan. 3. IMF. Unit: New Taiwan Dollar (NTD)

In 2002 the government launched another benefit regulation named the Senior Welfare Benefit Interim Regulation for the senior citizens who are excluded from the aforementioned regulations. Each eligible senior citizen can receive NT$3,000 every month. However, a few senior citizens are still excluded such as: 1. those who have been in receipt of government care; 2. those who have received their retirement pension from the public sector; 3. those who have received other benefits from the government[26]; 4. those whose total personal income was more than NT$500,000 in the last tax year; 5. those whose entire property in terms of land and building exceeds 5 million NTD; 6. those who are in the jail. Criteria 2, 4, and 5 exclude the affluent and criterion 3 excludes those people who have claimed other benefits from the government under the terms of to social justice. However, this regulation was

[26] This criterion excludes those senior citizens who have received benefits from the second regulations of EWA, SFWBIR, and the regulations for senior veterans.

abolished in 2008 after the start of the National Pension Scheme. The time scale of the regulations is shown as Table 5-3.

Table 5-3 Time table of welfare regulations of senior citizens

Welfare regulation	Date of launch	Final amendment	Remark
Elderly Welfare Act	26th January 1980	31st January 2007	-------
Farmer health Insurance	23rd June 1989	26th June 2002	-------
Senior Farmer Welfare Benefit Interim Regulation	19th May 1995	20th July 2007	-------
Senior Welfare Benefit Interim Regulation	22nd May 2002	18th June 2003	Were abolished on 30th September 2008
National Pension Scheme	8th August 2007	-------	Were implemented on 1st October 2008

Table 5-4 reveals that the proportion of senior citizens claiming benefits increases over time. After the Senior Welfare Benefit Interim Regulation was implemented, the proportion rose to over 50 percent. In 2003 the proportion of senior citizens was 12.33 percent covered by Elderly Welfare Act, 32.43 percent by the Farmer Welfare Benefit Interim Regulation, and 30.49 percent by the Senior Welfare Benefit Interim Regulation.

The total proportion covered by the above regulations is 71.2 percent. Given that government policies tend to increase certain senior-citizen benefit, the income structure of senior citizens changes over time as displayed in Table 5-5. In 1993 the most crucial income source for senior citizens was from their children, followed by, in importance, payment of interest or capital, retirement pension, wages, government benefits, and transfers from relatives or friends. In 2003 and 2005 the top three sources became children, government benefits, and retirement pension. Income from children becomes the main source from 1993 to 2005. However, government benefits become the second income source for senior citizens after 2002.

Table 5-4 Statistics of benefits (Unit: NT$1,000)

	EWA				SFWBIR		SWBIR		Total population ages at 65 or older	Percentage of people getting these benefits
	Low income household		Middle income household							
Year	Persons	Amount	Persons	Amount	Persons	Amount	Persons	Amount	Persons	%
1995	-------	-------	-------	-------	315192	5,627,721	-------	-------	1,631,054	19.32
1996	19,788	1,491,603	253,090	14,076,108	366,059	12,426,828	-------	-------	1,691,608	37.77
1997	19,158	1,371,896	137,919	7,609,775	425,947	12,426,828	-------	-------	1,752,056	33.28
1998	19,575	1,368,339	172,277	7,609,775	441,665	14,210,445	-------	-------	1,810,231	35
1999	19,366	1,377,131	172,117	8,617,172	588,429	15,742,716	-------	-------	1,865,472	41.81
2000	19,602	1,383,558	185,362	9,042,202	635,838	24,327,396	-------	-------	1,921,308	43.76
2001	18,699	1,335,955	162,512	8,487,905	656,460	23,188,599	-------	-------	1,973,357	42.45
2002	18,233	1,299,330	164,159	8,693,324	669,779	23,761,377	424,966	15,066,420	2,031,300	62.87
2003	17,798	1,273,324	156,153	8,606,150	677,048	24,129,852	636,583	19,104,373	2,087,734	71.25
2004	15,653	1,127,580	140,793	8,132,419	688,840	32,107,394	692,950	24,190,000	2,150,475	71.53
2005	15,327	1,093,639	132,746	7,835,611	696,808	33,198,715	746410	26222000	2216804	71.78

Source: Department of Statistics, Ministry of the Interior

Table 5-5 Income sources of senior citizens

The economical source of senior citizens (unit: degree of importance)						
Survey year	Children	Retired pension	Wage	Benefits	Interest gain	Relations, friends
1993	52.3	14.76	6.60	1.61	17.25	0.86
1996	48.28	17.55	7.30	6.37	13.15	0.40
2000	47.13	15.39	13.72	12.33	9.26	0.53
2002	51.72	17.35	11.81	22.58	12.23	0.55
2005	53.37	14.15	11.78	33.34	10.79	0.56

Source: Department of Statistics, Ministry of the Interior

5.3.3 Motivation for Investigation

The retired workers in Taiwan are usually eligible for two pensions. One is the retirement pension from the specified occupational scheme. The other is the contributing retirement pension financed by employees and employers. However, not all retired people are eligible to receive the retirement pension from their company if they do not fulfil the retirement criteria even if they have paid into the pension every month[27]. The pensions secure economic independence for retired people and, additionally, can lighten the economic burden of their offspring. Economic independence for retired people not only secures their status in the family but also implies a certain freedom and self-respect. For a poor family, pensions can secure their basic living.

Each of the social welfare schemes specific to a particular occupation usually includes the retirement pension. However, Farmer Health Insurance is the only occupational scheme without a retirement pension. This is the reason for the government implementing the Senior Farmer Welfare Benefit Interim Regulation. Though SFWBIR is a social welfare benefit, it can also be regarded as the retirement pension for the senior farmers. The difference between SFWBIR benefit and

[27] There are two kinds of retirement in the company. One is voluntary retirement. The other one is forced retirement. The criteria of former one are as follows: 1. 55 years old or older and have worked in a company for at least 15 years; 2. Have worked in a company for at least 25 years; 3. 60 years old or older and have worked in a company for at least 10 years. The criteria of latter one are as follows: 1. Achieve 65 years old; 2. 55 years old or older and physical or mental problem is too severe to work.

retirement pension in occupational schemes is that the amount of former one is fixed, whereas the latter one depends on their contribution.

The interest of this chapter is to investigate whether or not the intervention of SFWBIR benefit improves the health status and happiness of the senior farmers compared with the workers in other occupations whose insurance includes a retirement pension. The hypothesis in this chapter is that SFWBIR improves the health status and happiness of the senior farmers. In other words, the absolute income improves the health status and happiness of the senior farmers.

Using SFWBIR benefit as an instrument possesses several advantages. First, it is easy to use the criteria of SFWBIR to partition samples to treatment group and control group. Second, it covers approximate one third of senior citizens. Third, the retired age of covered individuals is more flexible than other occupations because there is no legally retired age for farmers. Thus, the retirement effects can be excluded from the analysis of SFWBIR benefit. Accordingly, the Senior Farmer Welfare Benefit Interim Regulation can be a good quasi-experimental instrument. If it has a significant impact on the health status and happiness of the senior farmer, indirectly, it can be postulated that the gain in absolute income affects the health status and happiness of the senior farmers.

The quasi-experimental methods applied in this chapter are difference-in-differences, difference-in-difference-in-differences (DiDiD) and regression-discontinuity. Difference-in-differences and regression-discontinuity are popular methods to identify a causal relationship. In the difference-in-differences design, how to select treatment group and control group randomly influences the result of the estimates. However, in the regression-discontinuity design, the individuals around the cut-off point are assumed to be identical. Thus, the problem of randomization is negligible. In order to achieve more robust estimates, more control groups are included in the analysis which is difference-indifference-in-differences estimation.

5.4 Identification strategy

The central issue in the evaluation of public policies is to separate their causal effect from the confounding effect of other factors influencing the outcome of interest. Random assignment of units to the intervention defines the treatment and control groups that are equivalent in all respects, except for their treatment status. Thus, the policy effects can be acquired in a straight way. However, in practice, random assignment is not always practicable. Experimental methods may reveal the causality between two variables because they assign the treatment and control groups randomly through the experimental design. It makes these two groups more comparable. Nevertheless, randomized field experiments are usually costly and sample size is usually small. Moreover, there are still some potential problems for experimental data in practice, such as failure to randomize, failure to follow the treatment protocol, and so on. The sample size of non-experimental data set, such as household survey or health status survey, is usually large but it is difficult to assign the observations into the appropriately comparable groups due to the lack of randomization. Thus, the quasi-experimental design becomes a good method to identify the casual effect between two variables when the researchers use non-experimental data. It is the one that looks similar to experimental design though it lacks the randomization which is the key issue in experimental design. However, the advantages are that it is not as costly as experimental design and, on the other hand, it can offer more precise interpretation of causality than the traditionally econometric methods. Difference-in-differences and regression-discontinuity designs are two methods that are used frequently. The following sections introduce these two designs.

5.4.1 Difference-in-differences (DiD)

The quasi-experimental method commonly used in social science is difference-in-differences. It compares the outcomes between treatment and control groups. Thus, the assumption needed on their context is that there is no contemporaneous shock to health and happiness of the treatment group during 1989 to 1996. Due to non-random assignment, there may be differences between two groups prior to programme. Comparing the changes between differences before and after intervention can eliminate confounding factors and isolate the treatment. The evaluation of policy in difference-in-differences design is defined as Eq. (5.1):

$$(5.1)\quad \Delta^{policy} = (Y_{treatment}^{after\ \ policy} - Y_{treatment}^{before\ \ policy}) - (Y_{control}^{after\ \ policy} - Y_{control}^{before\ \ policy})$$

where Δ^{policy} presents the effect of policy on variables. The term in the two brackets presents the difference before and after the policy intervention in treatment and control groups respectively.

There is a strong assumption in the difference-in-differences design which presumes that treatment group and control group have a common time trend (the time trends for two groups are parallel) which captures the wider changes in society which are unrelated to the particular policy we are interested in evaluating. The common time trend can be subtracted in the Eq. (5.1). However, the estimated policy impact would be bias if this assumption did not hold. The estimate of intervention impact would not only present the effect of intervention but also include the difference in trend between the control and treatment group.

The assumption is more likely verified when we look at the small time periods. However, in this chapter the time period is 7 years between two waves employed to estimation. It is doubted that treatment group (senior farmers) and control group (non-senior farmers) have the common trend during 7 years. The common time trend assumption can be tested by implementing "placebo" difference-in-differences estimation, which is defined as using the data of two waves before to intervention implement a difference-in-differences estimate, however, in this chapter the placebo difference-in-differences robustness check is not feasible because of the limitation of data. Thus, regression discontinuity method is employed as a robust check because regression discontinuity is feasible with one wave data after intervention and only the sample around the cut-off point, a threshold of treatment group selection, is selected into the regression. Thus, it avoids the common time trend assumption. If the results obtained from difference-in-differences and regression discontinuity are consistent, we can deduce that the common trend assumption is held in this study.

5.4.2 Regression-Discontinuity Design (RD)

Although it is not an experimental process, Regression discontinuity possesses the advantage of the property of randomization near the cut-off point. It defines the characteristic that the probability of receiving treatment changes discontinuously as a function of one or more underlying variables.

The original notion is to measure the gap before and after the policy or event. Let (Y_1, Y_0) be the potential outcomes when the individual does and does not participate in the programme, respectively. The treatment effect of programme is β defined by the difference between these two potential outcomes, Y_1-Y_0. However, it is not possible to observe Y_1 and Y_0 for the same individual at the same time because each individual is only exposed to one situation, either in programme or not. Let I be the binary variables for the treatment status, which I = 1 for participants and I = 0 for non-participants.

If the assignment is a random process, the following condition in Eq. (5.2) holds

$$(5.2) \quad (Y_1, Y_0) \perp I$$

where Y_1 and Y_0 are independent of I. The attractive characteristic of randomization is that the difference between the mean outcomes for participation and non-participation identifies the mean impact of programme

$$(5.3) \quad \beta = E(Y_1 \mid I = 1) - E(Y_0 \mid I = 0)$$

The regression-discontinuity design arises when the status of participation depends on an observable individual characteristic s and the probability of participation is known to be discontinuous at a point of s. However, a continuous random variable s on the real line is required. If $\bar{s}$ is the discontinuity point, then a regression-discontinuity design is expressed as Eq.(5.4)

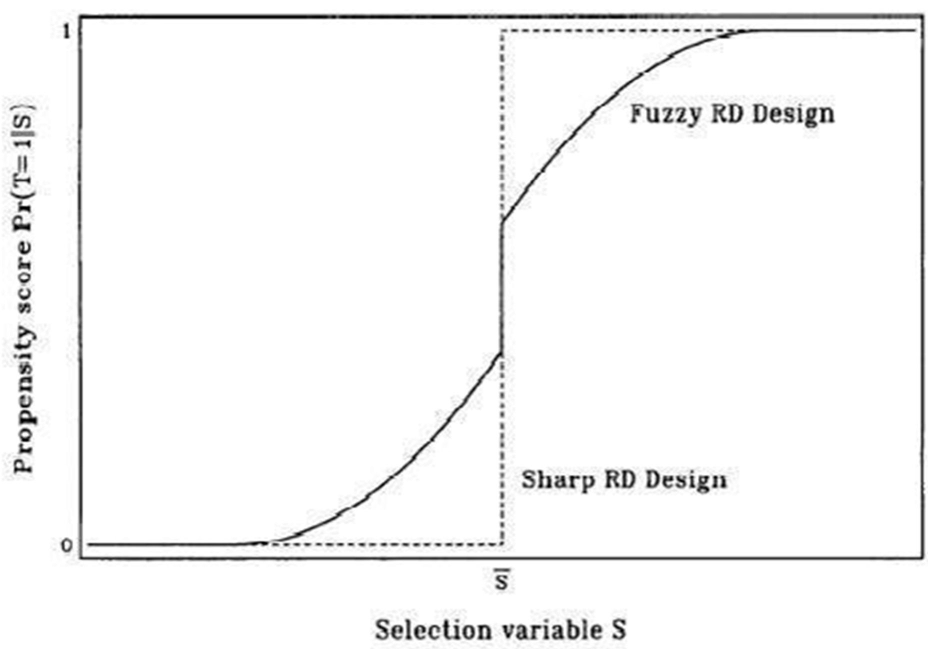
$$(5.4) \quad \Pr[I = 1 \mid \bar{s}^{+}] \neq \Pr[I = 1 \mid \bar{s}^{-}]$$

where the $\bar{s}^{+}$ and $\bar{s}^{-}$ refer to those individuals marginally above and below $\bar{s}$, respectively. In order to simplify the presentation, but without loss of generality, only the case in which the probability of participation increases as S crosses the threshold $\bar{s}$ is considered. Thus, Eq. (5.5) can be inferred from Eq. (5.4).

$$(5.5) \quad \Pr[I = 1 \mid \bar{s}^{+}] - \Pr[I = 1 \mid \bar{s}^{-}] > 0$$

Moreover, there are two types of regression-discontinuity design, sharp and fuzzy regression-discontinuity designs. Trochim (1984) distinguishes the difference between shape regression-discontinuity and fuzzy regression-discontinuity according to the size of discontinuity shown in Eq. (5.5). If the probability of participation conditional on *s* increases from zero to one when the *s* crosses the threshold $\overline{s}$, it is a sharp regression-discontinuity design. The variable *s* is the only one determinant for individuals to decide whether or not to enter in the programme. However, the fuzzy regression-discontinuity occurs when the size of the discontinuity at $\overline{s}$ is smaller than one and it implies that *s* is no longer the only one determinant of assignment to the treatment group. The assignment to treatment group may be affected by the observable and unobservable characteristics of individuals. The sharp regression-discontinuity design is a special case of fuzzy regression-discontinuity design. Figure

Figure 5.1 Assignment in the sharp (dashing) and fuzzy (solid) RD designs



5.1[28] illustrates the idea of regression-discontinuity design.

There is a growing literature using this method to analyse the impact of policies. Van Der Klaauw (2002) applies regression-discontinuity design to investigate the impact of financial aid on the college enrolment. Hahn et al. (1999) evaluate the effects of an antidiscrimination law on the employment of a minority using sharp regression-discontinuity design. Blundell et al. (2002) also use regression-discontinuity model to evaluate the employment impact of a mandatory job searcher programme. McCrary and Royer (2006) apply the regression-discontinuity method to investigate the relationship between maternal date of birth and infant health through the education route. Overall, the regression-discontinuity design has been used in many topics. It can circumvent the problems of randomization and endogeneity. The fuzzy regression-discontinuity model also can overcome the problem of self-selection if the information is available. Another advantage is that cross-sectional data can be used in this method if the data are limited.

Two types of regression-discontinuity designs can be expressed by using regression equations. The following expression is following Hahn et al. (2001). Consider the following equation under the absence of endogenous problem. The i denotes individual i, $\alpha_i \equiv Y_{0i}$, a function of s_i, and $\beta_i \equiv Y_{1i} - Y_{0i}$. α_i equals to $\alpha(s_i)+\varepsilon_i$.

$$(5.6) \quad Y_i = \alpha_i + I_i \beta + u_i$$

With a sharp design, treatment I_i depends in a deterministic way on some observable variable s_i, $I_i = f(s_i) = 1\{s_i \geq s_0\}$, where s_i is a continuum of values and the point s_0 and it is assumed to be known that $f(s)$ is discontinuous at s_0. In the empirical work of section 5.6.4, the sharp design is used due to the property of policy intervention.

[28] Figure 5.1 is cited from Van Der Klaauw (2002).

As for a fuzzy design, I_i is a random variable given s_i, hence, the determinant function is defined as $f(s) \equiv E[I_i \mid s_i = s] \equiv \Pr[I_i = 1 \mid s_i = s]$, and the conditional probability is known to be discontinuous at s_0. The common feature is both designs view the probability of joining treatment group, $\Pr[I_i = 1 \mid s_i]$, as a function of s_i and it is discontinuous at s_0. The treatment effect, β, can be obtained by Eq. (5.7)

$$\text{(5.7)} \quad \begin{aligned} \lim_{s \downarrow s_0} E[Y_i \mid s] - \lim_{s \uparrow s_0} E[Y_i \mid s] &= \{\lim_{s \downarrow s_0} E[\alpha_i \mid s] - \lim_{s \uparrow s_0} E[\alpha_i \mid s]\} \\ &+ \beta\{\lim_{s \downarrow s_0} E[I_i \mid s] - \lim_{s \uparrow s_0} E[I_i \mid s]\} + \{\lim_{s \downarrow s_0} E[u_i \mid s] - \lim_{s \uparrow s_0} E[u_i \mid s]\} \end{aligned}$$

They (Hahn et al., 2001) make some assumptions to rationalize the regression-discontinuity design on identifying causal effects.

Assumption (5.1): $E[\alpha_i \mid s]$ is continuous in s at s_0.

Assumption (5.2): The conditional mean function $E[u \mid s]$ is continuous at s_0.

Thus, the Eq. (5.7) can be expressed as Eq. (5.8)

$$\text{(5.8)} \quad \beta = \frac{\lim_{s \downarrow s_0} E[Y_i \mid s] - \lim_{s \uparrow s_0} E[Y_i \mid s]}{\lim_{s \downarrow s_0} E[I_i \mid s] - \lim_{s \uparrow s_0} E[I_i \mid s]}$$

In the sharp regression-discontinuity design the term $\lim_{s \downarrow s_0} E[I_i \mid s] - \lim_{s \uparrow s_0} E[I_i \mid s] = 1$ so that the treatment effect simplifies to $\lim_{s \downarrow s_0} E[Y_i \mid s] - \lim_{s \uparrow s_0} E[Y_i \mid s]$. However, in the fuzzy regression-discontinuity design another assumption is imposed.

Assumption (5.3): The limits $I^+ \equiv \lim_{s \downarrow s_0} E[I_i \mid s]$ and $I^- \equiv \lim_{s \uparrow s_0} E[I_i \mid s]$ exist and $I^+ \neq I^-$.

This assumption implies that the discontinuity of $f(s)$ exists at point s_0.

The treatment effects can be re-expressed as Eq. (5.9) for sharp regression-discontinuity design and Eq. (5.10) for fuzzy design.

$$(5.9) \quad \beta = Y^+ - Y^-$$

$$(5.10) \quad \beta = \frac{Y^+ - Y^-}{I^+ - I^-}$$

where $Y^+ \equiv \lim_{s \downarrow s_0} E[Y_i \mid s]$, $Y^- \equiv \lim_{s \uparrow s_0} E[Y_i \mid s]$, $I^+ = \lim_{s \downarrow s_0} E[I_i \mid s]$ and $I^- = \lim_{s \uparrow s_0} E[I_i \mid s]$.

The treatment effect identified above is the case of constant treatment effect (β instead of β_i). It assumes everyone receives the same effect when exposed in the programme. However, it is a strong assumption. An alternative assumption is the variable treatment effect. Assumption (5.4) is needed in order to define the average treatment effects.

Assumption (5.4): The average treatment effect function $E[\beta_i \mid s]$ is continuous at s_0.

Suppose I_i is independent of β_i conditional on s_i being near s_0 and assumptions (5.1), (5.3), and (5.4) hold. The mean of treatment effects is as Eq. (5.11).

$$(5.11) \quad E[\beta_i \mid s] = \frac{Y^+ - Y^-}{I^+ - I^-}$$

With a sharp design, $E[\beta_i \mid s] = Y^+ - Y^-$.

The above inferences build on a strong assumption that the decision of participation of individuals is not affected by the treatment effect. It may be unrealistic that individuals do not take the future treatment gain into consideration when they make the decision whether or not to participate in the programme.

The Eq. (5.11) is biased without that strong assumption. However, another assumption is necessary.

Assumption (5.5): (i) (β_i, $I_i(s)$) is jointly independent of s_i near s_0.

(ii) There exists $\varepsilon > 0$ such that $I_i(s_0 + e) \geq I_i(s_0 - e)$ for all $0 < e < \varepsilon$.

Under the assumptions (5.1), (5.3), and (5.5), Eq. (5.12) is obtained and it can identify the local average treatment effect (LATE) at s_0.

$$(5.12) \quad \lim_{e \to 0^+} E[\beta_i \mid I_i(s_0 + e) - I_i(s_0 - e) = 1] = \frac{Y^+ - Y^-}{I^+ - I^-}$$

Now consider the case of endogenous circumstance. The assignment variable s correlated with the outcome Y. Rewrite Eq. (5.6) and get Eq. (5.13)

$$(5.13) \quad Y_i = \alpha_i + I_i \beta + k(s_i) + \omega_i$$

where $\omega_i = Y_i - E[Y_i \mid I_i, s_i]$. $k(s_i)$ is a control function in the outcome equation and it is a conditional mean function $E[u|I,s]$ (Heckman and Robb, 1985). This approach requires the correct specification $k(s)$ of control function; otherwise, it is likely to produce inconsistent estimates. Van Der Klaauw (2002) suggests two estimation approaches to circumvent this problem. The first approach is to adopt a semi-parametric specification for the control function or use local or nonparametric regression around the cut-off point s_0. The second approach is to estimate the one-sided limits such as Eq. (5.10) and Eq. (5.11). McCrary and Royer (2006) document the four one-side limits estimate supposed by Hahn et al. (2001) can circumvent the problem of endogeneity.

An important attraction of the regression-discontinuity design is that, by only exploiting its relationship with a single variable, one does not have to choose a functional form for the way in which other variables affect the dependent variable. Meanwhile, it also possesses the property of randomization but this property only exists near the cut-off point. Increasing the interval around the cut-off point is likely to produce a bias in the effect estimation, especially when the assignment variable itself is related to the outcome variable conditional on treatment status. Thus, its extrapolation is a drawback in this design.

5.5 Data

The data used in this chapter is also taken from the Survey of Health and Living Status of the Elderly which has been introduced in last chapter. Due to the policy intervention implemented in 1995, the first wave (1989) and third wave (1996) which are before and after policy intervention are selected whereas the second wave (1993) is not used because the number of observation younger than 65 years old is not enough for the estimations. The observations used in this chapter are at the age between 50 and 75 years old. The first wave and third wave comprise 3564 observations and 4484 observations respectively.

The dependent variables used in this chapter are self-assessed health, depression measurement of CES-D, and life satisfaction which are the same as those in chapter 5. The absolute income hypothesis will be supportive if the policy intervention has a significant effect on self-assessed health and depression measurement of CES-D and, at once, income increasing happiness will also be supportive if the policy intervention has a significant effect on life satisfaction.

This data set comprises a number of detailed histories such as marital status, employment and retirement, and living arrangements/residence. The occupational history provides comprehensive information to assign observations to treatment and control groups according to the Senior Farmer Welfare Benefit Interim Regulation.

With the respect to the questionnaire of economic/financial well-being, the information of residence status, income, and expenditure is included. On the one hand, it is useful for distinguishing whether or not the individuals claim other government benefits. On the other hand, it can also reveal how the individuals utilize their benefits if they are eligible.

The other explanatory variables used in this chapter are age, gender, number of children, and dummies for education levels, marital status, family scales, regions, and job types. The observations in the treatment group in first wave number 486 and in the third wave number 216. Table 5-6 shows the detailed sample size in each group and Table 5-7 depicts the sample statistics. The sample statistics of two separate years (1989 and 1996) are shown in Table A-6.

Table 5-6 The sample size in each group

	1989			1996		
Group / Age	Farmer	Non-farmer Labour	Manu-facturing Labour	Farmer	Non-farmer Labour	Manu-facturing Labour
65-75 years	486	1345	165	216	1853	55
Under 65 years	292	1094	182	343	1698	319

In Table 5-7, the treatment is the sub-group of elder farmer (age is 65 or older) and control 1 is the sub-group of farmer whose age is less than 65. In the non-farmer worker group and the manufacturing worker group, control 2 means the sub-group of elder non-farmer worker and elder manufacturing worker (age is 65 or older) respectively and control 3 means the sub-group of non-farmer worker and manufacturing worker (age is less than 65) respectively.

In each group, the mean of self-assessed health and life satisfaction of the elder sub-group is lower than its counterpart. It implies that the elder people in each group have lower likelihood to report good health and have lower mean of life satisfaction. As for depression scale, the elder observations in farmer group and in the manufacturing worker group report lower mean of depression scale than its counterpart (5.991 vs. 6.561 and 5.528 vs. 5.956) whereas it is contrary in the non-farmer worker group (6.982 vs. 6.439).

Table 5-7 Sample statistics (pooling 1989 and 1996)

	Farmer Group		Non-Farmer Worker Group[29]		Manufacturing Worker Group	
	Treatment	Control 1	Control 2	Control 3	Control 2	Control 3
	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
Health Indicators						
SAH	0.355 (0.479)	0.398 (0.49)	0.342 (0.475)	0.441 (0.497)	0.376 (0.485)	0.505 (0.5)
CES-D	5.991 (4.313)	6.561 (4.578)	6.982 (4.774)	6.439 (4.267)	5.528 (4.425)	5.956 (3.824)
LS	6.352 (2.426)	6.549 (2.389)	6.184 (2.566)	6.334 (2.498)	6.092 (2.316)	6.183 (2.429)
Educational dummy						
Illiteracy	0.481 (0.5)	0.376 (0.485)	0.382 (0.486)	0.26 (0.439)	0.373 (0.485)	0.204 (0.403)
Primary S.	0.466 (0.499)	0.57 (0.495)	0.409 (0.492)	0.502 (0.5)	0.464 (0.5)	0.645 (0.479)
Junior H.S.	0.037 (0.189)	0.033 (0.179)	0.096 (0.295)	0.112 (0.315)	0.118 (0.324)	0.088 (0.283)
Senior H.S.	0.01 (0.099)	0.017 (0.131)	0.062 (0.242)	0.077 (0.267)	0.032 (0.176)	0.048 (0.214)
University	0.004 (0.065)	0.003 (0.056)	0.049 (0.215)	0.048 (0.213)	0.014 (0.116)	0.016 (0.125)
Postgraduate	-	-	0.001 (0.025)	0.001 (0.038)	-	-
Marital status dummy						
Married	0.728 (0.445)	0.841 (0.366)	0.633 (0.482)	0.803 (0.398)	0.632 (0.483)	0.832 (0.374)
Divorce	0.02 (0.14)	0.008 (0.088)	0.026 (0.159)	0.035 (0.183)	0.055 (0.228)	0.048 (0.214)

[29] This group excludes the government employees, teachers, military men and three specialist groups, namely doctors, lawyers and certificated public accountant. The government employees, teachers and military employees receive a stable and substantial occupational benefit. However, the three specialists are usually at the top of the income distribution. Their observable characteristics are different from those of the other employees.

Widow	0.244 (0.43)	0.140 (0.347)	0.296 (0.457)	0.127 (0.333)	0.255 (0.437)	0.078 (0.268)
Single	0.006 (0.075)	0.011 (0.104)	0.045 (0.207)	0.035 (0.184)	0.059 (0.236)	0.042 (0.201)
Age	69.43 (3.069)	59.98 (3.593)	69.66 (2.98)	58.78 (4.244)	68.92 (2.769)	57.66 (4.497)
Squire of age	4830.6 (422.12)	3610.8 (418.47)	4861.1 (416.75)	3472.7 (488.3)	4758 (384.8)	3345.4 (514.2)
Male	0.694 (0.461)	0.624 (0.485)	0.522 (0.5)	0.512 (0.5)	0.673 (0.47)	0.747 (0.435)
Family scale dummy						
1-4 people	0.439 (0.497)	0.422 (0.494)	0.513 (0.5)	0.479 (0.5)	0.477 (0.501)	0.437 (0.497)
5-10 people	0.496 (0.5)	0.517 (0.5)	0.449 (0.497)	0.479 (0.5)	0.486 (0.501)	0.521 (0.5)
Over 10 people	0.066 (0.248)	0.061 (0.24)	0.038 (0.191)	0.042 (0.2)	0.036 (0.188)	0.042 (0.201)
Regional dummy						
North	0.11 (0.313)	0.09 (0.286)	0.316 (0.465)	0.305 (0.461)	0.395 (0.49)	0.291 (0.455)
Middle	0.439 (0.497)	0.45 (0.498)	0.314 (0.464)	0.308 (0.462)	0.323 (0.469)	0.321 (0.476)
South	0.352 (0.478)	0.389 (0.488)	0.304 (0.46)	0.328 (0.47)	0.241 (0.429)	0.341 (0.475)
East	0.1 (0.3)	0.071 (0.257)	0.066 (0.248)	0.058 (0.234)	0.041 (0.199)	0.046 (0.209)
Job type dummy						
Self-employed	0.363 (0.481)	0.503 (0.5)	0.08 (0.271)	0.159 (0.366)	0.041 (0.199)	0.129 (0.335)
Family Business	0.009 (0.092)	0.014 (0.119)	0.009 (0.096)	0.013 (0.112)	0.005 (0.067)	0.026 (0.16)
Employee	0.044 (0.206)	0.07 (0.255)	0.092 (0.288)	0.286 (0.452)	0.286 (0.453)	0.666 (0.472)
Retire	0.011 (0.106)	0.009 (0.097)	0.127 (0.333)	0.052 (0.221)	0.118 (0.324)	0.05 (0.219)
Others[30]	0.573 (0.5)	0.403 (0.491)	0.693 (0.461)	0.49 (0.5)	0.55 (0.499)	0.129 (0.335)

[30] The observations in this group are the one who is not included in self-employed, family business, employed, and retired groups.

No. of children	5.422 (2.129)	4.678 (1.742)	4.498 (2.226)	3.992 (1.76)	4.365 (2.161)	3.759 (1.723)
Sample size	702	635	3198	2792	220	501

5.6 Empirical framework

The information on benefit claim from the Senior Farmer Welfare Benefit Interim Regulation is unavailable in this data set so it is necessary to assume that all the eligible individuals claim the benefit from the Senior Farmer Welfare Benefit Interim Regulation. Nevertheless, this is not a strong assumption though it ignores the problem of self-selection bias. However, there are some reasons to believe that this problem negligible here. Recall the criterion of claiming the benefit from the Senior Farmer Welfare Benefit Interim Regulation in 1996. The criterion is that the senior citizens who have participated in farmer scheme for at least 6 months and do not claim any pensions from other social schemes or any benefits from government. The other social schemes which had been implemented in 1996 are government employee and labour schemes. People who are senior farmers and have claimed pensions from these two social schemes are not eligible to claim benefit from the Senior Farmer Welfare Benefit Interim Regulation. Otherwise, they have to forego the pensions. If the intention to forego the pensions from other social schemes exists, then self-selection bias will be generated. However, the nature of pensions and benefits are different. Pensions represent the rewards of previous payment. It is a form of contribution rather than a gift whereas benefits are cost free. Thus, it is not rational to forego the pensions for benefits because of the opportunity cost of benefits. The information of claiming the pensions from other social schemes is available from occupational history. Similarly, self-selection bias would be negligible because the senior citizens are less prone to forego other government benefits to achieve the criterion of the Senior Farmer Welfare Benefit Interim Regulation because the amount of this benefit was not more than other benefits in 1996. However, the only reason for individuals to change their benefit tendency would be if the amount of specified benefit is more than the other benefits. The benefit of the Senior Farmer Welfare Benefit Interim Regulation in

1996 was NT$3,000[31]. It was less than other government benefits, for example, the veteran benefit and disability benefit. Hence, changing the benefit is not rational because of the change cost.

Two quasi-experimental designs are employed in this chapter. One is difference-in-differences and its extension, difference-in-difference-in-differences. The other one is regression-discontinuity.

5.6.1 Difference-in-differences estimation

To estimate the effect of the Senior Farmer Welfare Benefit Interim Regulation on senior farmer' health status, the farmer group is selected into the estimation and partitioned into two subgroups according to age. The farmers at the age of 65 years or older are assigned to the treatment group; the others are assigned to the control group. The DiD analysis assumes that the path of health outcome for both groups would not be systematically different in the absence of intervention. The observed characteristics between these two groups are similar apart from the mean age.

The test of Eq. (5.14) > 0 implies that the Senior Farmer Welfare Benefit Interim Regulation improves the senior farmer's health status and life satisfaction.

$$
\begin{aligned}
(5.14)\quad \Delta^{SFWBIR} &= (H_{treatment}^{Afetr\ SFWBIR} - H_{treatment}^{Before\ SFWBIR}) - (H_{control}^{After\ SFWBIR} - H_{control}^{Before\ SFWBIR}) \\
&= (H_{treatment}^{After\ SFWBIR} - H_{control}^{After\ SFWBIR}) - (H_{treatment}^{Before\ SFWBIR} - H_{control}^{Before\ SFWBIR})
\end{aligned}
$$

Thus, the pooling sample observed in 1989 and 1996 is used to estimate the effect of Senior Farmer Welfare Benefit Interim Regulation. The equation is as Eq. (5.15):

$$(5.15)\quad H_{it} = \alpha_0 + \delta_1 SFWBIR_{it} + \delta_2 SC_{it} + \delta_3 SFWBIR_{it} * SC_{it} + \alpha_1 X_{it} + v_{it}$$

[31] In the same year, the lowest living expense in Taiwan province, Taipei city, and Kaohsiung city was 5,400, 6,640, and 5,400 NTD respectively. The exchange rate was 1 USD=27.45 NTD and 1GBP=1.56 USD. The GDP per capita was 13,376 USD.

where i indexes individuals and t indexes year. H_i is the response of self-assessed health status, the score of depression or life satisfaction, *SFWBIR* is a dummy for the period after implementation of Senior Farmer Welfare Benefit Interim Regulation, *SC* is a dummy for senior citizens, *X* is a vector of observable individual characteristics, and v is a random error term. The effect of intervention Eq. (5.15) can be expressed as: $\Delta^{SFWBIR} = [(\delta_1 + \delta_2 + \delta_3) - \delta_2] - [\delta_1 - 0] = \delta_3$. The coefficient δ_3 measures the difference-in-differences defined in Eq. (5.14).

5.6.2 Difference-in-difference-in-differences estimation (DiDiD)

In order to obtain a more robust analysis, difference-in-difference-in-differences approach is used. DiDiD includes more compared groups in the estimation than DiD. The advantage of DiDiD approach is the ability to eliminate one more systematic influence than DiD during the estimating period. For example, systematic influence on farmer and on senior citizens, DiD approach only excludes the former systematic influence whereas it is unable to eliminate the latter one. DiDiD approach is able to eliminate two systematic influences to acquire more precise results.

In DiDiD estimation, the sample is partitioned into two groups according to occupation. The farmer group is compared with the non-farmer group. In addition, the farmer group is also compared with the group of manufacturing workers because manufacturing workers have a similar socioeconomic background to farmers. In the non-farmer group several occupations are excluded, for example, government employees, teachers, military personnel and three specialist occupations, namely doctors, lawyers and certified public accountants (CPA). The welfare of the government employees, teachers and military personnel is secured by the government and their jobs are more stable than other occupations. The three specialists usually have a higher educational level and higher socioeconomic status.

Each group can obtain the effect of The Senior Farmer Welfare Benefit Interim Regulation by using difference-in-differences design shown in Eq. (5.16) and Eq. (5.17). Further, the effect from the farmer group subtracts the effect from non-farmer group, which is shown in Eq. (5.18). DiDiD and DiD share the same idea and DiDiD can be regarded as the extension of DiD. The purpose of aDiDing multiple control groups is to isolate the treatment effects from potential factors unrelated to Senior Farmer Welfare Benefit Interim Regulation.

$$(5.16)\quad \Delta_{Farmer}^{SFWBIR} = (H_{SC}^{After\ SFWBIR} - H_{SC}^{Before\ SFWBIR}) - (H_{Non-SC}^{After\ SFWBIR} - H_{Non-SC}^{Before\ SFWBIR})$$

$$(5.17)\quad (\Delta_{Non-Farmer}^{SFWBIR} = (H_{SC}^{After\ SFWBIR} - H_{SC}^{Before\ SFWBIR}) - (H_{Non-SC}^{After\ SFWBIR} - H_{Non-SC}^{Before\ SFWBIR})$$

$$(5.18)\quad \Delta^{SFWBIR} = \Delta_{Farmer}^{SFWBIR} - \Delta_{Non-Farmer}^{SFWBIR}$$

where Δ^{SFWBIR} and H has been defined above. The indicators of sub- and superscripts present the senior citizens and non-senior citizens before and after Senior Farmer Welfare Benefit Interim Regulation. The difference-indifference-indifferences estimator can be expressed within a regression framework with the pooling data observed in 1989 and 1996. The regression is as Eq. (5.19):

$$\begin{aligned}(5.19)\quad H_{it} = {} & \beta_0 + \gamma_1 SFWBIR_{it} + \gamma_2 SC_{it} + \gamma_3 FHI_{it} + \gamma_4 SFWBIR_{it} * SC_{it} \\ & + \gamma_5 SC_{it} * FHI_{it} + \gamma_6 SFWBIR_{it} * FHI_{it} + \gamma_7 SFWBIR_{it} * SC_{it} * FHI_{it} \\ & + \beta_1 X_{it} + \varepsilon_{it}\end{aligned}$$

where *FHI* is an indicator variable for the group of farmer, ε is a random error term and other variables have been defined in Eq. (5.15). The effect of The Senior Farmer Welfare Benefit Interim Regulation in Eq. (5.19) can be expressed as ΔSFWBIR = $\{[(\gamma_1+\gamma_2+\gamma_3+\gamma_4+\gamma_5+\gamma_6+\gamma_7)-(\gamma_2+\gamma_3+\gamma_5)]-[(\gamma_1+\gamma_3+\gamma_6)-\gamma_3]\}-\{[(\gamma_1+\gamma_2+\gamma_4)-\gamma_2]-[\gamma_1-0]\} = \gamma_7$. The coefficient γ_7 measures the difference-in-difference-in-differences defined in Eq. (5.18).

5.6.3 Dependent and explanatory variables

Three dependent variables are specified: (1) individual self-assessed health status, (2) individual scale of depression and (3) individual scale of life satisfaction. The first dependent variable is a dichotomous variable with good and poor self-assessed health status. The original variable has five categorical responses: very good, good, fair, poor and very poor. The value of 1 is assigned to the responses of very good and good and otherwise 0. Owing to the binary response model, the observed variable, H_{it}, in Eq. (5.19) is dominated by a latent variable, $H_{it}*$, which can be regarded as the health stock of the individuals. The individuals would report their health status as being very good or good when their health stock is above 0; otherwise fair, poor and very poor. Thus, a binary variable indicating the sign of H_{it}^{*} is observed:

$$(5.20) \quad H_{it} = \begin{cases} 1 & if\ H_{it}^{*} > 0 \\ 0 & if\ H_{it}^{*} \leq 0 \end{cases}$$

The second dependent variable is the scale of CES-D. Its range is between 0 and 30. The third dependent variable is the scale of LS and its scale is between 0 and 10. X_{it} is a vector of demographic and economic characteristics of the individual: age, square of age, gender, number of children, and dummies for education level, marital status, family scales, regions, and job types, respectively.

With respect to estimation, Probit model is used in SAH analysis and ordinary least square estimate (OLS) are used in CES-D and LF analyses.

5.6.4 Regression discontinuity design

In the regression-discontinuity design only the data of 1996 is needed and, at that time, the Senior Farmer Welfare Benefit Interim Regulation had been implemented for one year. The treatment is assigned based on individual's age and 65 years old is a threshold:

$$I_i = 1\{s_i \geq 65\}$$

and estimation equation is as Eq. (5.21):

$$(5.21) \quad H_i = \alpha_i + \beta_i I_i + \lambda(s_i) + \varsigma_i$$

where λ(.) is a control function to correct endogeneity (s_i and ς_i). The specific functional form of λ(.) depends on distribution of assumption. Meanwhile, α_i equals to $\alpha(s_i)+\varepsilon_i$. On the one hand, substitute $\alpha(s_i)+\varepsilon_i$ into Eq. (5.21). Under general conditions, on the other hand, λ(.) is continuous. Eq. (5.21) is rewritten as Eq. (5.22).

$$(5.22) \quad H_i = \tilde{\alpha}(s_i) + \beta I_i + \mu_i$$

where $\tilde{\alpha} \equiv \alpha(s_i) + \lambda(s_i)$ and $\mu_i \equiv \varepsilon_i + \varsigma_i$. The sharp regression-discontinuity design is used to estimate the treatment effect. The average treatment effect of the Senior Farmer Welfare Benefit Interim Regulation is defined as

$$(5.23) \quad E[\beta_i \mid s] = H^+ - H^-$$

The two one-sided limits are estimated by using local linear regression (LLR) in Eq. (5.11) which is the average treatment effect. Local linear regression has better boundary property than the traditional kernel regression estimator and its bias does not depend on the design density of the data (Hahn et al., 2001). The estimator for H^+ in Eq. (5.23) is given by $\hat{a}$ in Eq. (5.24).

$$(5.24) \quad (\hat{a}, \hat{b}) \equiv \underset{a,b}{\operatorname{argmin}} \sum_{i=1}^{n} (Y_i - a - b(s_i - s_0))^2 K\left(\frac{s_i - s_0}{h}\right) 1(s_i \geq s_0)$$

where, $K(.)$ is a kernel function and $h > 0$ is a suitable bandwidth.

5.7 Empirical Results

5.7.1 Difference-in-differences estimates

The top columns (labelled baseline model) of Table 5-8 report the effect of the Senior Farmer Welfare Benefit Interim Regulation on self-assessed health status without controlling the other characteristics in the difference-in-differences estimate. The baseline model shows that the Senior Farmer Welfare Benefit Interim Regulation has no statistically significant effects on treatment group. In the bottom columns of Table 5-8, the other control variables identified in Eq. (5.15) are included. In the full specification model, the coefficient of the Senior Farmer Welfare Benefit Interim Regulation on the treatment group is negative but it is not statistically significant at 5%. Education, but only the junior high school level, contributes the self-assessed health status. People whose education level is at junior high school level have a higher probability of reporting good self-assessed health status compared with illiterate subjects, holding other characteristics constant. The dummies of marital status do not have statistically significant effects on self-assessed health status.

Age has a non-significantly negative effect on self-assessed health status, holding other characters constant. However, the gender dummy has a significantly positive effect on self-assessed health. The probability of males to report good self-assessed health is higher than that of females, holding other characteristics constant.

With respect to regional dummies, the north and the south have positive and significant effects on self-assessed health compared with the east and they are significant at 1% and 5%, respectively. The self-employed and retired people have a higher probability of reporting good self-assessed health than those who are defined as the category of others.

Table 5-9 shows the results of estimates replacing the dependent variable with CES-D. The Senior Farmer Welfare Benefit Interim Regulation has negative effects on CES-D of treatment group in the baseline model. However, the coefficient is not statistically significant.

In the full specification estimate, the effect of Senior Farmer Welfare Benefit Interim Regulation on treatment group has similar results to the baseline estimate. It is negative but not significant at 5%. With respect to other control variables, median family type, and self-employed job type have significant effects on depression and these variables are all significant at 1%. With respect to family size and job type, median families (5-10 people) report significantly (0.85 point) lower depression compared with small families (1-4 people). Self-employed people report 1.068 units lower depression score compared with people who are classed group others.

Table 5-10 presents the results of estimating life satisfaction. In the baseline model the effect of the Senior Farmer Welfare Benefit Interim Regulation on the treatment group is positive but not significant at 5%. In the full specification model it is also positive and not statistically significant. The education dummies are positive apart from the university dummy but only the primary school and senior high school dummies are significant. The people whose education is at primary school and senior high school levels report 0.335 point and 1.301 points higher for life satisfaction, respectively, compared with illiterate subjects, holding other characteristics constant.

With respect to marital status, the marriage and widowhood have the same and significant effects on the life satisfaction. Married people report higher scores of life satisfaction than single people by 2.675 points, holding other characteristics constant. However, widows also report 1.925 higher scores for life satisfaction than single people, holding other variables constant. Self-employed and retired people report higher life satisfaction and their coefficients are 0.64 and 1.687, respectively.

Table 5-8 Difference-in-differences Estimate of SFWBIR on SAH

Baseline Model		
	Coef.	Std. Err.
SFWBIR (post 1995)	0.018	0.102
SC (Senior Citizen)	-0.124	0.096
SFWBIR*SC	0.046	0.147
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	-0.020	0.127
SC (Senior Citizen)	-0.025	0.138
SFWBIR*SC	-0.051	0.171
Other Characteristics		
Education		
Primary school	0.061	0.085
Junior high school	0.560**	0.211
Senior high school	0.069	0.317
University	0.493	0.583
Postgraduate	-	-
Marital Status		
Marriage	0.833	0.631
Divorce	1.145	0.695
Widow	0.784	0.636
Age	-0.138	0.129
Age2	0.001	0.001
Gender	0.211*	0.091
Family size		
5-10 persons	0.055	0.078
More than 10 persons	0.071	0.156
Regional Dummy		
North	0.573**	0.180
Middle	0.232	0.147
South	0.363*	0.148
Job type		
Self-employed	0.570**	0.083
Family business	0.517	0.337
Employed	0.290	0.165
Retire	1.100**	0.363
No. of children	0.035	0.020
Sample Size	1295	
LR Chi2	121.41	
Pseudo R2	0.071	

** Statistically significant at the 1% level * Statistically significant at the 5% level

Table 5-9 Difference-in-differences Estimate of SFWBIR on CES-D

Baseline Model		
	Coef.	Std. Err.
SFWBIR (post 1995)	1.732**	0.359
SC (Senior Citizen)	0.033	0.316
SFWBIR*SC	-0.623	0.512
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	1.882**	0.420
SC (Senior Citizen)	-0.198	0.454
SFWBIR*SC	-0.566	0.560
Other Characteristics		
Education		
Primary school	-0.235	0.281
Junior high school	0.104	0.687
Senior high school	-0.896	1.055
University	0.977	1.966
Postgraduate	-	-
Marital Status		
Marriage	-2.710	1.562
Divorce	-2.591	1.856
Widow	-1.761	1.583
Age	0.145	0.426
Age2	-0.001	0.003
Gender	-0.401	0.298
Family size		
5-10 persons	-0.854**	0.257
More than 10 persons	-0.736	0.518
Regional Dummy		
North	-0.627	0.581
Middle	0.261	0.459
South	0.362	0.466
Job type		
Self-employed	-1.068**	0.275
Family business	0.381	1.142
Employed	-0.320	0.540
Retire	-0.105	1.181
No. of children	0.012	0.065
Sample Size	1282	
F-statistics	4.56	
R2	0.077	

** Statistically significant at the 1% level * Statistically significant at the 5% level

Table 5-10 Difference-in-differences Estimate of SFWBIR on LS

Baseline Model		
	Coef.	Std. Err.
SFWBIR (post 1995)	0.021	0.198
SC (Senior Citizen)	-0.247	0.184
SFWBIR*SC	0.189	0.291
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	-0.017	0.233
SC (Senior Citizen)	0.061	0.248
SFWBIR*SC	0.071	0.312
Other Characteristics		
Education		
Primary school	0.335*	0.155
Junior high school	0.560	0.376
Senior high school	1.290*	0.602
University	-0.085	1.059
Postgraduate	-	-
Marital Status		
Marriage	2.675**	0.842
Divorce	1.143	1.020
Widow	1.925*	0.853
Age	0.005	0.236
Age2	-0.0001	0.002
Gender	0.039	0.165
Family size		
5-10 persons	0.268	0.142
More than 10 persons	0.496	0.283
Regional Dummy		
North	-0.053	0.320
Middle	0.146	0.254
South	0.415	0.259
Job type		
Self-employed	0.640**	0.152
Family business	0.547	0.636
Employed	-0.216	0.297
Retire	1.687*	0.660
No. of children	0.056	0.036
Sample Size	1219	
F-statistics	5.02	
R2	0.088	

** Statistically significant at the 1% level * Statistically significant at the 5% level

5.7.2 Difference-in-difference-in-differences estimates

In order to get more robust results, more comparison groups are included in the estimate and the results are shown in Table 5-11 to Table 5-16. The extra comparison groups in Table 5-11 to Table 5-13 are the non-farmer group. In Table 5-14 to Table 5-16, the extra comparison groups are the manufacturing group.

5.7.2.1 Farmer group vs. Non-farmer group

In Table 5-11 the baseline estimate presents the effect of the Senior Farmer Welfare Benefit Interim Regulation on self-assessed health of treatment group is positive but not statistically significant at 5% level.

In the full specification of farmers and non-farmer groups case, the effect of the Senior Farmer Welfare Benefit Interim Regulation on self-assessed health of treatment group is similar to that in baseline estimate, positive but not statistically significant at 5% level.

With respect to other characteristics, the estimates of education dummies are all positive and statistically significant at 1% to self-assessed health compared with illiteracy. The estimates are 0.233, 0.478, 0.623 and 0.673, respectively. The age variable has a negative effect which is significant at 1% level on self-assessed health. It reduces the probability of reporting good self-assessed health and the association is nonlinear. The gender dummy, all the regional dummies, and job type dummies apart from family business are significant at 1% level. The dummy of family business and the number of children are significant at 5% level. The probability for males to report good self-assessed health is higher than that of females, holding other characteristics constant. Finally, the regional dummies are all positive and significant at 1% level. The people in north, middle and south areas have higher probability to report good health status than those in east, respectively. As for the job type, self-employed, family business, employed, and retired people have higher probability to report good self-assessed health compared with others, respectively. The number of children also increases the probability to report good SAH.

Table 5-12 presents the results of the effects of the Senior Farmer Welfare Benefit Interim Regulation on CES-D of treatment group. In the baseline model, the effect of the Senior Farmer Welfare Benefit Interim Regulation on CES-D of treatment group is negative and significant at 5% level. In the full specification of farmers and non-farmer groups, it maintains negative but not significant at 5% level. The effect of the Senior Farmer Welfare Benefit Interim Regulation reduces 0.992 point of depression of senior farmers compared with the non-farmer group.

With respect to other control variables, all education dummies are negative and are significant at 1% and 5% levels, respectively, apart from postgraduate dummy. People whose education is at primary school, junior high school, senior high school, and university levels report lower score of depression compared with the illiteracy. The estimates are -0.572, -0.712, -1.122, and -1.352, respectively. The higher education level people achieve the lower depression score people report. The other significant dummies, either at 1% or 5% level, are gender, family scales with 5-10 people and more than 10 people, all the dummies of job type except for family business, and number of children. Males have less depression than females by 0.699, holding other variables constant, respective. People in the medium family (5-10 people) and large family (more than 10 people) have less depression than those in the small family by 0.589 point and 0.992 point, respectively, holding other variables constant. The people who are self-employed, employed, and retired have less depression than others by 0.777 point, 0.709 point, and 0.506 point, respectively. The number of children also reduces the depression. When a family increases one child, the depression score of the household members drops 0.109 point on average.

Table 5-11 Difference-in-difference-in-differences Estimate of SFWBIR on SAH (Farmer group vs. Non-Farmer group)

	Coef.	Std. Err.
Baseline Model		
SFWBIR (post 1995)	-0.102*	0.05
SC (Senior Citizen)	-0.252**	0.052
FHI	-0.181*	0.084
FHI*SC	0.128	0.109
FHI*SFWBIR	0.12	0.113
SFWBIR*SC	-0.015	0.068
FHI*SC*SFWBIR	0.062	0.162
Full Specification		
SFWBIR (post 1995)	-0.227**	0.063
SC (Senior Citizen)	-0.002	0.067
FHI	-0.125	0.090
FHI*SC	0.056	0.113
FHI*SFWBIR	0.130	0.117
SFWBIR*SC	0.030	0.082
FHI*SC*SFWBIR	0.024	0.168
Other Characteristics		
Education		
Primary school	0.233**	0.04
Junior high school	0.478**	0.062
Senior high school	0.623**	0.075
University	0.673**	0.089
Postgraduate	-	-
Marital Status		
Marriage	-0.027	0.125
Divorce	-0.142	0.152
Widow	-0.055	0.129
Age	-0.167**	0.050
Age2	0.001**	0.0004
Gender	0.131**	0.039
Family size		
5-10 persons	0.038	0.034
More than 10 persons	0.065	0.08
Regional Dummy		
North	0.337**	0.072
Middle	0.226**	0.070
South	0.282**	0.070
Job type		
Self-employed	0.377**	0.047
Family business	0.324*	0.146
Employed	0.397**	0.049
Retire	0.201**	0.064
No. of children	0.018*	0.009
Sample Size	6819	
LR Chi2	565.46	
Pseudo R2	0.062	

** Statistically significant at the 1% level * Statistically significant at the 5% level

Table 5-12 Difference-in-difference-in-differences Estimate of SFWBIR on CES-D (Farmer group vs. Non-Farmer group)

	Coef.	Std. Err.
Baseline Model		
	Coef.	Std. Err.
SFWBIR (post 1995)	1.479*	0.165
SC (Senior Citizen)	0.239	0.176
FHI	0.061	0.278
FHI*SC	-0.206	0.361
FHI*SFWBIR	0.253	0.395
SFWBIR*SC	0.593*	0.236
FHI*SC*SFWBIR	-1.217*	0.564
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	1.645**	0.212
SC (Senior Citizen)	-0.571*	0.223
FHI	0.17	0.303
FHI*SC	-0.050	0.378
FHI*SFWBIR	0.199	0.394
SFWBIR*SC	0.497	0.271
FHI*SC*SFWBIR	-0.992	0.561
Other Characteristics		
Education		
Primary school	-0.572**	0.13
Junior high school	-0.712**	0.210
Senior high school	-1.122**	0.250
University	-1.352**	0.299
Postgraduate	-4.366	2.501
Marital Status		
Married	-0.582	0.409
Divorce	0.464	0.503
Widow	-0.025	0.422
Age	-0.019	0.166
Age2	0.0006	0.001
Gender	-0.699**	0.131
Family size		
5-10 persons	-0.589**	0.111
More than 10 persons	-0.992**	0.265
Regional Dummy		
North	-0.264	0.231
Middle	0.134	0.225
South	-0.033	0.226
Job type		
Self-employed	-0.776**	0.160
Family business	-0.685	0.495
Employed	-0.709**	0.164
Retire	-0.506*	0.217
No. of children	-0.109**	0.029
Sample Size	6782	
F-Statistics	23.84	
R2	0.090	

** Statistically significant at the 1% level * Statistically significant at the 5% level

The last part in this section is the estimate of life satisfaction. Table 5-13 provides the results of the effect of the Senior Farmer Welfare Benefit Interim Regulation on life satisfaction of the treatment group. In the baseline model, the estimates of the Senior Farmer Welfare Benefit Interim Regulation on life satisfaction of treatment group are positive but not significant at 5% level. However, in the full specification, it turns to negative and still not significant at 5% level.

With the respect to other variables, the education dummies apart from postgraduate dummy, married and divorced dummies, and two dummies of family size, regional dummies of middle and south, self-employed and retired dummies, and the number of children are significant either at 1% or 5% level. People with the education at primary school, junior high school, senior high school and university levels have higher life satisfaction than those who are illiteracy by 0.669 point, 1.259 points, 1.487 points and 1.415 points, respectively, holding other variables constant. Married people have higher life satisfaction and divorced people have lower life satisfaction than single people by 0.763 point and 0.615 point, respectively, holding other variables constant. People in the medium family (5-10 people) and large family (more than 10 people) have higher life satisfaction than in small family (1-4 people) by 0.243 point and 0.576 point, respectively, holding other variables constant. The people living in the middle and south have higher life satisfaction than those living in the east area by 0.266 point and 0.405 point. As for the job type, the self-employed and retired people usually have higher life satisfaction than those categorized in others by 0.494 point and 0.506 point, respectively. The number of children in the family also increases the life satisfaction of individuals by 0.106 point

Table 5-13 Difference-in-difference-in-differences Estimate of SFWBIR on LS

(Farmer group vs. Non-Farmer group)

Baseline Model		
	Coef.	Std. Err.
SFWBIR (post 1995)	0.065	0.101
SC (Senior Citizen)	-0.238*	0.104
FHI	0.242	0.164
FHI*SC	-0.009	0.211
FHI*SFWBIR	-0.044	0.222
SFWBIR*SC	0.16	0.139
FHI*SC*SFWBIR	0.028	0.322
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	-0.158	0.12
SC (Senior Citizen)	0.165	0.126
FHI	0.079	0.17
FHI*SC	-0.027	0.212
FHI*SFWBIR	0.074	0.223
SFWBIR*SC	0.244	0.154
FHI*SC*SFWBIR	-0.094	0.32
Other Characteristics		
Education		
Primary school	0.669**	0.074
Junior high school	1.259**	0.120
Senior high school	1.487**	0.143
University	1.415**	0.170
Postgraduate	-1.660	1.696
Marital Status		
Marriage	0.763**	0.236
Divorce	-0.615*	0.289
Widow	0.293	0.243
Age	-0.063	0.095
Age2	0.0003	0.0007
Gender	-0.117	0.075
Family size		
5-10 persons	0.243**	0.063
More than 10 persons	0.576**	0.149
Regional Dummy		
North	-0.070	0.135
Middle	0.266*	0.131
South	0.405**	0.132
Job type		
Self-employed	0.494**	0.092
Family business	0.520	0.288
Employed	0.181	0.093
Retire	0.506**	0.125
No. of children	0.106**	0.017
Sample Size	6422	
F-Statistics	20.84	
R2	0.084	

** Statistically significant at the 1% level   * Statistically significant at the 5% level

5.7.2.2 Farmer group vs. Manufacturing group

The baseline model in Table 5-14 shows the effect of the Senior Farmer Welfare Benefit Interim Regulation on self-assessed health of treatment group is negative and non-significant at 5% level. In the full specification, it maintains negative and statistically non-significant. The significant variables are the dummies of junior high school, senior high school, gender, regional dummies, and the self-employed and employed dummies. These dummies are all significant at 1% level apart from the dummy of middle region. People with the education at junior high school and senior high school levels have higher probability to report good health status than those who are illiteracy, holding other variables constant. Males have higher probability to report good health status than females. People in the north, middle, and south areas have higher probability to report good health status compared with those in the east. Finally, the self-employed and retired people have higher probability to report good health status compared with those categorized in others, respectively.

The baseline model in Table 5-15 shows that the Senior Farmer Welfare Benefit Interim Regulation reduces the depression of treatment group and it is significant at 5% level. In the full specification model, the effect of the Senior Farmer Welfare Benefit Interim Regulation on CES-D of treatment group maintains negative and significant at 5% level. The Senior Farmer Welfare Benefit Interim Regulation reduces the depression of treatment group by 1.923 points.

With respect to the control variables, only the dummy of family size of 5-10 persons, and the dummies of self-employed and employed job types are significant either at 1% or 5% level. Finally, people in the middle family (5-10 persons) report less depression than those in small family size (1-4 persons) by 0.679 point, holding other variables constant. The self-employed and employed people have less depression than those categorized in others by 1.066 points and 0.677 point, respectively.

The baseline model in Table 5-16 shows the effect of the Senior Farmer Welfare Benefit Interim Regulation on life satisfaction of treatment group is positive but not significant at 5% level. In the full specification model, it maintains positive and not significant at 5% level.

With respect to other variables, the significant dummies are primary school, junior high school, senior high school, large family size, self-employed job type, retirement, and the number of children at 1% and 5% levels, respectively. People whose education is at primary school, junior high school, and senior high school levels report higher life satisfaction than those with illiteracy by 0.349 point, 0.871 point, and 1.352 points, respectively, holding other variables constant. People report higher life satisfaction in large family size than in small family by 0.608 point. Self-employed and retired people have higher life satisfaction than those categorized in others by 0.64 point and 0.768 point, respectively. Finally, the number of children also increases individual's life satisfaction and its coefficient is 0.069.

Table 5-14 Difference-in-difference-in-differences Estimate of SFWBIR on SAH (Farmer group vs. Manufacturing group)

	Coef.	Std. Err.
Baseline Model		
SFWBIR (post 1995)	0.091	0.12
SC (Senior Citizen)	-0.302*	0.141
FHI	-0.239	0.122
FHI*SC	0.78	0.17
FHI*SFWBIR	-0.073	0.157
SFWBIR*SC	0.047	0.236
FHI*SC*SFWBIR	-0.0002	0.278
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	-0.110	0.154
SC (Senior Citizen)	-0.181	0.169
FHI	-0.096	0.142
FHI*SC	0.150	0.181
FHI*SFWBIR	0.071	0.171
SFWBIR*SC	0.116	0.262
FHI*SC*SFWBIR	-0.142	0.293
Other Characteristics		
Education		
Primary school	0.096	0.072
Junior high school	0.599**	0.143
Senior high school	0.579**	0.206
University	0.597	0.344
Postgraduate	-	-
Marital Status		
Marriage	0.005	0.276
Divorce	-0.108	0.323
Widow	0.020	0.285
Age	-0.138	0.097
Age2	0.001	0.001
Gender	0.197**	0.075
Family size		
5-10 persons	0.033	0.063
More than 10 persons	0.067	0.133
Regional Dummy		
North	0.569**	0.141
Middle	0.263*	0.128
South	0.377**	0.129
Job type		
Self-employed	0.552**	0.077
Family business	0.363	0.245
Employed	0.458**	0.102
Retire	0.291	0.178
No. of children	0.010	0.017
Sample Size	1958	
LR Chi2	181.35	
Pseudo R2	0.069	

** Statistically significant at the 1% level   * Statistically significant at the 5% level

Table 5-15 Difference-in-difference-in-differences Estimate of SFWBIR on CES-D (Farmer group vs. Manufacturing group)

Baseline Model		
	Coef.	Std. Err.
SFWBIR (post 1995)	1.119**	0.379
SC (Senior Citizen)	-0.344	0.459
FHI	0.414	0.407
FHI*SC	0.377	0.557
FHI*SFWBIR	0.613	0.522
SFWBIR*SC	1.505	0.839
FHI*SC*SFWBIR	-2.129*	0.983
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	1.549**	0.498
SC (Senior Citizen)	-0.995	0.540
FHI	0.269	0.459
FHI*SC	0.620	0.578
FHI*SFWBIR	0.373	0.554
SFWBIR*SC	1.363	0.833
FHI*SC*SFWBIR	-1.923*	0.933
Other Characteristics		
Education		
Primary school	-0.339	0.230
Junior high school	-0.670	0.451
Senior high school	-0.931	0.648
University	-1.400	1.100
Postgraduate	-	-
Marital Status		
Marriage	-0.627	0.868
Divorce	0.243	1.020
Widow	0.202	0.896
Age	0.202	0.309
Age2	-0.001	0.002
Gender	-0.442	0.237
Family size		
5-10 persons	-0.679**	0.200
More than 10 persons	-0.810	0.429
Regional Dummy		
North	-0.573	0.436
Middle	0.044	0.389
South	0.026	0.395
Job type		
Self-employed	-1.067**	0.244
Family business	0.494	0.799
Employed	-0.667*	0.325
Retire	-0.290	0.576
No. of children	-0.048	0.053
Sample Size	1941	
F-Statistics	6.09	
R2	0.079	

** Statistically significant at the 1% level * Statistically significant at the 5% level

Table 5-16 Difference-in-difference-in-differences Estimate of SFWBIR on LS

(Farmer group vs. Manufacturing group)

	Coef.	Std. Err.
Baseline Model		
SFWBIR (post 1995)	0.321	0.242
SC (Senior Citizen)	0.038	0.269
FHI	0.562*	0.245
FHI*SC	-0.285	0.326
FHI*SFWBIR	-0.3	0.313
SFWBIR*SC	-0.154	0.47
FHI*SC*SFWBIR	0.343	0.553
Full Specification		
	Coef.	Std. Err.
SFWBIR (post 1995)	-0.023	0.287
SC (Senior Citizen)	0.355	0.308
FHI	0.337	0.262
FHI*SC	-0.316	0.329
FHI*SFWBIR	-0.002	0.318
SFWBIR*SC	0.042	0.477
FHI*SC*SFWBIR	0.016	0.535
Other Characteristics		
Education		
Primary school	0.349**	0.132
Junior high school	0.871**	0.258
Senior high school	1.352**	0.373
University	0.311	0.618
Postgraduate	-	-
Marital Status		
Marriage	0.817	0.488
Divorce	-0.508	0.583
Widow	0.057	0.505
Age	-0.018	0.177
Age2	0.0001	0.001
Gender	-0.041	0.137
Family size		
5-10 persons	0.167	0.115
More than 10 persons	0.608*	0.243
Regional Dummy		
North	-0.041	0.251
Middle	0.201	0.224
South	0.333	0.228
Job type		
Self-employed	0.640**	0.141
Family business	0.452	0.464
Employed	0.311	0.187
Retire	0.768*	0.329
No. of children	0.069*	0.03
Sample Size	1849	
F-Statistics	5.61	
R2	0.077	

** Statistically significant at the 1% level   * Statistically significant at the 5% level

5.7.3 Regression-discontinuity estimates

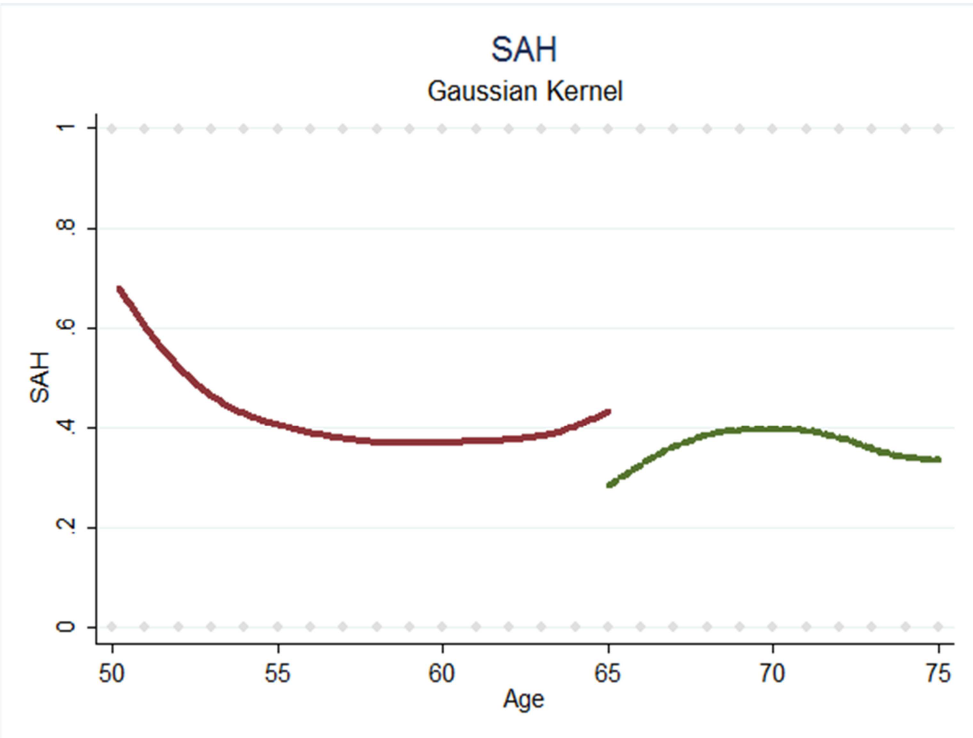
The conditional mean is estimated nonparametrically by means of local linear regression when choosing both kernel and bandwidth. The Gaussian kernel is used and several alternative choices of the bandwidth are considered to check the robustness of the findings.

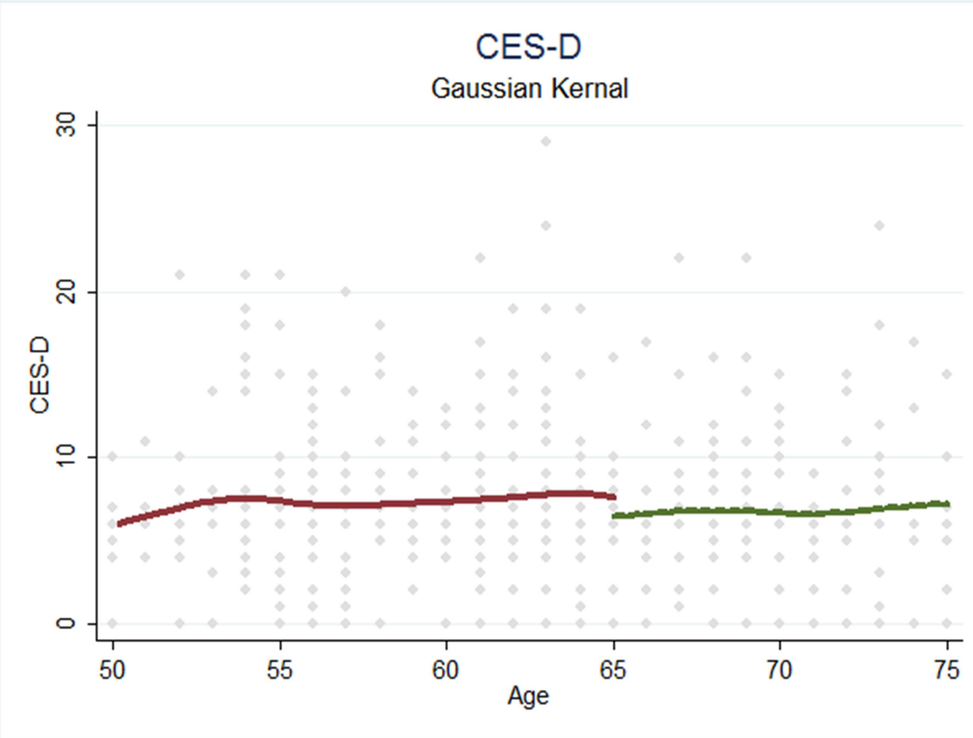
Table 5-17 Estimate of SFWBIR on Health Indicators and Life Satisfaction
(boostrap standard errors reported in parentheses)

Bandwidth	SAH	CES-D	LS
1.1	-0.165 (0.244)	-0.471 (1.849)	1.518 (1.114)
1.766	-0.15 (0.177)	-1.184 (1.472)	1.28 (0.743)
3.532	-0.082 (0.09)	-1.299 (1.089)	0.999 (0.605)

1.766 is the bandwidth obtained from “normal reference rule-of-thumb”

Figure 5.2 The impact of SFWBIR on SAH, CES-D, and LS (bandwidth=1.766)




CES-D
Gaussian Kernal
CES-D
0
10
20
30
50
55
60
65
70
75
Age

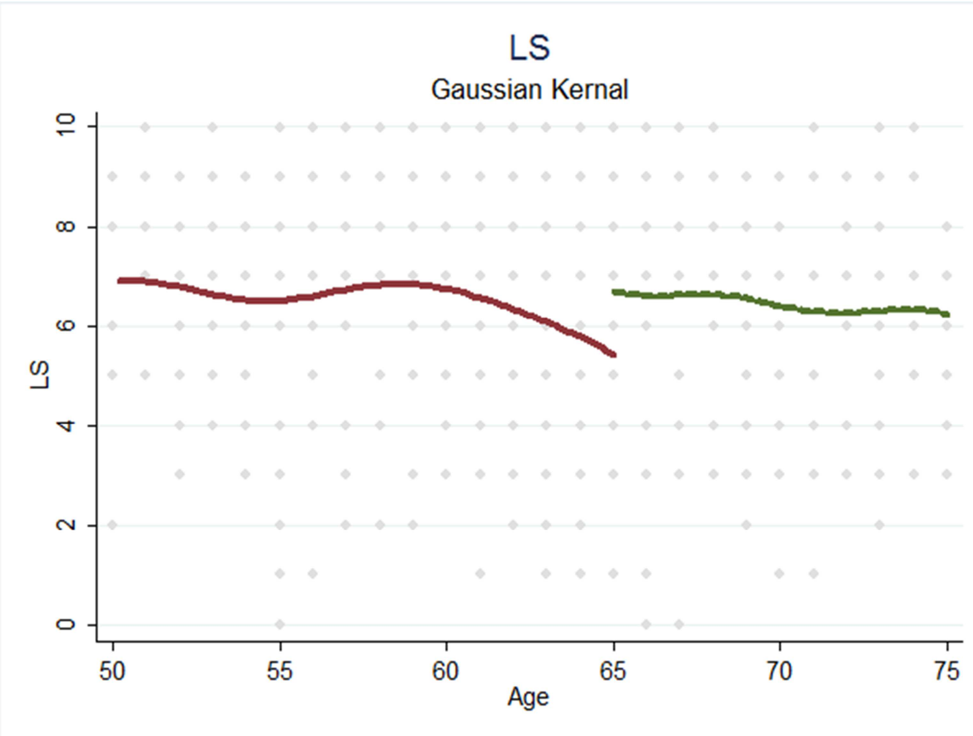

LS
Gaussian Kernal
LS
0
2
4
6
8
10
50
55
60
65
70
75
Age

Figure 5.2 shows that the Senior Farmer Welfare Benefit Interim Regulation has a positive impact on life satisfaction but a negative impact on self-assessed health and CES-D. However, Table 5-1717 reveals that the Senior Farmer Welfare Benefit Interim Regulation does not have a statistically significant impact on the self-assessed health, CES-D and life satisfaction. Meanwhile, the estimates are not sensitive to the choice of bandwidth. The findings from regression-discontinuity design are consistent with the results of difference-in-differences which uses the same sample as that in regression-discontinuity design. The Senior Farmer Welfare Benefit Interim Regulation has no significant effects on self-assessed health, CES-D, and life satisfaction when the farmer group is the only sample for estimation. However, the result changes in the difference-in-difference-in-differences estimation which includes more comparison sub-groups.

5.8 Conclusion

This chapter uses two quasi-experimental methods, difference-in-differences and regression discontinuity, to identify the effect of the Senior Farmer Welfare Benefit Interim Regulation on self-assessed health status, depression, and life satisfaction of the treatment group, the senior farmers. However, regression discontinuity is only examined as robustness test instead of being the main analysis in this chapter because it has a strong assumption of a single discrete cut-off point (at age 65 in this chapter). It presumes that policy intervention is the only factor causing the health status change at 65 years old. But there may be other potential factors which cause the health status change at age 65, for example, retirement and the implementation of other social benefits for senior citizens. Though the two example factors are excluded from analysis in this chapter, there may have other potential factors which are not considered in this chapter. In this aspect, DiD provides a more precise estimate.

Some signs of the estimators of the Senior Farmer Welfare Benefit Interim Regulation on self-assessed health status and life satisfaction are not as expected but they are not statistically significant at 5% level. However, the sign of effect of the Senior Farmer Welfare Benefit Interim Regulation on depression within the treatment group is always negative and it is statistically significant at 5% level when farmers are compared with manufacturing workers. On the other hand, the regression discontinuity estimation provides the consistent results with those of difference-in-differences. The Senior Farmer Welfare Benefit Interim Regulation has no significant effect on the three indicators within the treatment group.

In summary, the pure cash injection policy has no significant effect on self-assessed health status and life satisfaction but has a significant effect on depression. It provides evidence indirectly that the absolute income hypothesis holds in terms of mental health. It also shows that absolute income is not a determinant of happiness.

People with education at high school level are usually healthier and happier compared with those who are illiterate. Males report better health status than females. Median family size (5-10 persons) decreases the depression. As for region, people in the north and south are healthier than those in east whereas the region is not a determinant of depression and life satisfaction. The urbanization of the east is less than that of the other regions, especially the north and the south. Two municipalities directly under the jurisdiction of the central Government are located in the north (Taipei city) and in the south (Kaohsiung city). It implies that people living in these two areas benefit from the greater resource allocation, especially health service. Thus, this finding that people in the north and south are healthier than those in the east is convincing. With respect to job type, self-employed people have better self-assessed health status, less depression, and more life satisfaction and employed people are healthier. Retirement improves self-assessed health status and life satisfaction only when the treatment and control groups are all farmers.

The purpose of the Senior Farmer Welfare Benefit Interim Regulation is to complete the old-age pension of the occupational insurance because the Farmer Health Insurance is the only occupational scheme without an old-age pension. The results provide the evidence that the absolute income hypothesis holds partially in Taiwanese society. The government still needs to make further efforts to investigate other auxiliary policies to make the senior welfare more comprehensive.

Gardner and Oswald (2007) find that income innovation of lottery has significant effects on improving mental wellbeing after two years. Comparing their finding to that in this chapter, it is partially consistent. The consistency is the exogenous income innovation has a significant effect on mental health but inconsistent part is that this effect is observed after one year in this thesis. Two reasons might explain this difference. First, the instruments of income innovation are different. Policy intervention is permanent and anticipated whereas lottery wins are a short-term and unanticipated impact. Secondly, the population concerned in this chapter is senior farmers whose socioeconomic status is relatively low. For those people, financial embarrassment likely causes depression. Income injection can immediately relieve somewhat stress. The security of economic status also raises self-esteem and family status of senior farmers. On the other hand, the anticipated effect after policy announcement might start to reduce somewhat stress. Thus, the observed policy effect in terms of depression is shorter than that in Gardner and Oswald (2007)

With respect to self-assessed health and life satisfaction, income might have lagged effects on both indicators whereas this chapter cannot reveal any information about lagged effects of two years or later. Only the first year after policy implement can be detected due to the limitation of data. For the population at low social strata, improving financial embarrassment will relieve living stress first and raise life satisfaction afterwards. On the other hand, look at the questionnaire of CES-D and life satisfaction in terms of time span (see Table A-4 and Table A-5). The questions of

CES-D focus on current mental status whereas the questions of life satisfaction focus not only on current status but also on the comparison of current status with the past, the evaluation of the whole life, and the expectation of future. Life satisfaction is an evaluation of a longer time span. Thus, the policy effect on life satisfaction might be ambiguous or be observed more slowly than that on depression. Thus, it is plausible that the policy might have a significant effect on life satisfaction after improving depression in this group. As for self-assessed health, income likely has a lagged effect on it due to the health investment after income increases.

Finally, this chapter provides the consistent results produced by difference-in-differences and regression discontinuity approaches which have different assumptions. However, the difference-in-difference-in-differences would provide more precise results when more comparison groups, particularly, with a similar background, are included because it is able to eliminate more systematic influence which is unrelated to the Senior Farmer Welfare Benefit Interim Regulation on the treatment group.

Chapter 6. Conclusion

The type of data is a determinant which causes the debates of health income hypotheses. Many previous studies use cross-national data to analyse and obtained the evidence to support the relative income hypothesis or income inequality hypothesis. However, the relative income hypothesis or income inequality hypothesis holding does not mean the absolute income hypothesis is false. Recently, more and more studies used micro-level survey data to investigate the same question. However, they did not find much evidence as aforementioned studies to support the relative hypothesis or the income inequality hypothesis. Table 2-1 presents this circumstance. Gravelle et al. (2002) remind the researchers to be careful if one wants to use aggregate data to analyse the individual mortality risk-income relationship. Unbiased estimators mainly build on linear individual health income relationship when aggregate data are used to infer individual health income relationship. Using micro-level data is able to avoid this problem and find more precise evidence.

This thesis is based on the argument of Gravelle et al. (2002). The nonlinear relationship between self-assessed health, depression, life satisfaction, respectively, and income is found in chapter 4. This finding implies that in Taiwanese studies the aggregate bias needs to be considered when aggregate data are used to infer individual health income relationship and it is consistent with the motivation of the proposed approach of combining aggregate data and individual data in Chapter 3. The difference between parametric estimations and nonparametric estimations is not only shown in the figures but the model specification test also shows that the parametric linear, quadratic, and cubic forms in terms of income are a misspecification in the estimations of depression and life satisfaction.

The absolute income hypothesis and the income inequality hypothesis are supportive in this thesis when long-run income and long-run Gini coefficient are the regressors under the assumption of health social gradient. This finding shows that health income hypotheses are not contradictory. Chapter 5 also provides the evidence to support that long-run income has a significant effect on mental health. Thus, the absolute income hypothesis is also supported after taking causality into consideration.

Though nonlinear relationships between three indicators and income are presented in chapter 4, a linearly horizontal relationship and a relatively linear relationship are found in the single female group in the case of depression and self-assessed health respectively. The policies relevant to social aids or social benefit for low income group might have ambiguous influence on depression relief for the other groups but it will not influence single females. The other social aids which are not relevant to income, for example, mental support and a regular visit by social workers, might improve their mental health. Taking money from high income population to provide public goods or other health services would raise the average probability to report good self-assessed health status when the single senior females are concerned. On the other hand, the policies for improving the wellbeing of the married population are more complicated because of their curvilinear health income relationship.

The policy intervention in chapter 5 is a long-run pure cash injection which is different from the intervention in the previous studies, for example, lottery wins or the Nobel Prizes. This thesis provides the evidence that long-run income can improve mental health one year after policy intervention even if it is just a small monthly amount (£70, this is approximately US$ 110). Gardner and Oswald (2007) conclude in their study that two years after lottery wins, medium-size lottery wins (£1000-£120,000, this is, up to approximately US$ 200,000) improves 1.4 GHQ points of mental wellbeing. Thus, the anticipated policy reform with small amount has a faster effect on mental wellbeing than unanticipated medium lottery wins.

This thesis focuses on testing the absolute income and the income inequality hypotheses. Above conclusion suggests that increasing absolute income and reducing income inequality are able to raise the average health status. When income increases, people can buy better health services and nutritious food, and meanwhile the financial pressure is also somewhat relieved which in turn is able to improve mental health and reduces suicide rates. When income inequality reduces, the potentially unstable factors influencing a society will decrease. It improves health status through the accumulation of social capital, the decrease of living stress from unstable society, and the increase of public investments such as education and health service.

Finally, this thesis is the study in Taiwanese case. Strictly speaking, policy implications are only directly applicable to Taiwan. One should always be careful of generalizing single-country studies to other countries, especially when they are very different. Considering the case of Taiwan, one might reasonably think that there is some chance that similar health income relationships might also hold in other areas in Asia, such as Japan and South Korea, but the mentioned note of caution should always be borne in mind.

Economic growth may not necessarily bring the improvements of economic circumstance uniformly across the population. Inappropriate design and implementation of income distribution will benefit the upper-income quantiles much more than the lower to the bottom income quantiles. The latter groups receive less benefit of economic growth and usually suffer worse health conditions. Hence, back to the original goodwill policies concerning income distributions and redistributions, a social assistant should ensure that the disadvantaged groups can enjoy the fruit of economic growth to increase the lower boundary of health standard, which ultimately raises the level of average health status of whole society.

What we know from this thesis is that it is too hasty to use the economic development as a watershed of the income hypotheses because the income hypotheses might coexist instead of being exclusionary. The prospectively relevant research needs to consider the aggregate bias when using Taiwanese data. With respect to income influence, a policy with long-run and small income is observed faster than medium income shock because the policy is anticipated. For the consequent directions for future research, it is worth to know how long the policy effect will last and there has any effect when the benefit increases.

Appendix

Table A-1 The definition of variables

Variables	Description
Deaths per 1000 people	The original mortality rate (the range is between 0 and 1)*1000
Mean of log disposable income 1	Mean of individual log disposable income equivalised by scale 1 within the county
Mean of square log disposable income 1	Mean of square of individual log disposable income equivalised by scale 1 at county level
Gini coefficient 1	Calculated from individual disposable income equivalised by scale 1 within the county
Mean of log disposable income 2	Mean of individual log disposable income equivalised by scale 2 within the county
Mean of square log disposable income 2	Mean of square of individual log disposable income equivalised by scale 2 within the county
Gini coefficient 2	Calculated from individual disposable income equivalised by scale 2 within the county
Age	Numerical variable
Gender	Dummy variable which assigns male to 1 and 0, otherwise
Edu 1	Education attendant is less than 1 year (illiteracy)
Edu 2	Education attendant is between 1 and 6 years (primary school)
Edu 3	Education attendant is between 7 and 9 years (junior high school)
Edu 4	Education attendant is between 10 and 12 years (senior high school)
Edu 5	Education attendant is more than 12 years (university, postgraduate, and equivalent degree)
Occu1	Professionals
Occu2	Clerks
Occu3	Technicians and associate professionals
Occu4	Service workers, shop and market sales labours
Occu5	Agricultural, animal, husbandry, forestry, and fishing labours
Occu6	Product machine operators and related labours
Occu7	Unemployment
Long-run mean of log disposable income 1	Mean of log disposable income (aggregated from individual disposable income which is equivalised by scale 1) of the county across time dimension
Long-run mean of log disposable income 2	Mean of log disposable income (aggregated from individual disposable income which is equivalised by scale 2) of the county across time dimension
Long-run mean of Gini coefficient 1	Mean of Gini coefficient (computed from individual disposable income which is equivalised by scale 1) of the county across time dimension
Long-run mean of Gini coefficient 2	Mean Gini coefficient (computed from individual disposable income which is equivalised by scale 2) of the county across time dimension

Table A-2 Robust estimation with income equivalent scale 1[†]

(original crude mortality rate)

	Fixed Effects		Population Averaged	
	Coef.	Robust Std. Err.	Coef.	Semi-robust Std. Err.
Mean of log disposable income	-0.001591	0.001254	-0.0016389	0.0012418
Mean of square log disposable income	0.0000885	0.0000631	0.0000917	0.0000625
Gini coefficient	0.0002455	0.0009992	0.0001932	0.0009565
Age	-0.0003938	0.0002096	-0.0003933	0.0002038
Square of age	6.88e-06*	2.72e-06	6.95e-06**	2.65e-06
Gender	0.0016168	0.0024541	0.0016271	0.0024818
Education				
Edu 2(1 - 6 years)	-0.0016458	0.0012558	-0.0015518	0.0011873
Edu 3(7 – 9 years)	0.0010489	0.0023551	0.0013359	0.0011873
Edu 4(10 – 12 years)	-0.0003456	0.001935	-0.0001038	0.0018775
Edu 5(More than 12 years)	-0.005729**	0.0017743	-0.0060443**	0.0017615
Occupation[††]				
Occu1	0.0065123	0.0032373	0.0067065*	0.0031488
Occu2	-0.0009155	0.0025416	-0.001351	0.002527
Occu3	0.0001453	0.0030895	-0.0004164	0.0030503
Occu4	-0.0016155	0.0017407	-0.0018865	0.0017255
Occu5	-0.00103	0.0013154	-0.0005855	0.001292
Occu6	0.0023784	0.0020123	0.0016698	0.0018712
Constant	0.0148407	0.0072587	0.0148962	0.0072295

† The equivalent scale is the number of household members.

†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.

* significant at 5% level; ** significant at 1% level

Table A-3 Robust estimation with income equivalent scale 2†

(original crude mortality rate)

	Fixed Effects		Population Averaged	
	Coef.	Robust Std. Err.	Coef.	Semi-robust Std. Err.
Mean of log disposable income	-0.0012512	0.0013653	-0.0012915	.0013543
Mean of square log disposable income	0.0000707	0.000066	0.0000734	0.0000655
Gini coefficient	0.000036	0.0010365	-6.97e-06	0.0009914
Age	-0.0003939	0.0002103	-0.0003932	0.0002044
Square of age	6.95e-06*	2.73e-06	7.01e-06**	2.66e-06
Gender	0.0017026	0.0024419	0.0017137	0.00247
Education				
Edu 2(1 - 6 years)	-0.0016267	0.0012899	-0.0015343	0.0012199
Edu 3(7 – 9 years)	0.0010285	0.0023536	0.0013086	0.0022269
Edu 4(10 – 12 years)	-0.0003098	0.0019827	-0.0000658	0.0019271
Edu 5(More than 12 years)	- 0.0055624*	0.0017924	- 0.0058742**	0.0017782
Occupation††				
Occu1	0.0065736	0.0032614	0.0067673*	0.0031708
Occu2	-0.0005251	0.0025207	-0.0009481	0.0025132
Occu3	0.0001945	0.0030714	-0.0003657	0.0030324
Occu4	-0.0015179	0.0017234	-0.0017889	0.0017107
Occu5	-0.0009908	0.0013121	-0.0005457	0.0012915
Occu6	0.0023116	0.0020294	0.0016069	0.0018826
Constant	0.0130812	0.0079782	0.0130868	0.0079693

† The formula of equivalent scale is (number of adult + 0.5* number of children)$^{0.9}$.

†† Occu1: professionals; Occu2: clerks; Occu3: technicians and associate professionals; Occu4: service workers, shop and market sales workers; Occu5: agricultural, animal, husbandry, forestry, and fishing workers; Occu6: product machine operators and related workers. The comparative group is unemployment.

* significant at 5% level; ** significant at 1% level

Table A-4 Questionnaire of CES-D

Do you have following feelings in the past one week?	No	Yes		
		Rare (1 day)	Sometimes (2-3 days)	Often (more than 3 days)
Have little desire to eat	0	1	2	3
Feel laborious when doing everything	0	1	2	3
Do not sleep well	0	1	2	3
Feel depressed	0	1	2	3
Feel lonely	0	1	2	3
Feel being treated unfriendly	0	1	2	3
Feel sad	0	1	2	3
Cannot be spirited up to do anything	0	1	2	3
Feel happy	3	2	1	0
Enjoy life	3	2	1	0

Note: the number in the table is the score of response

Table A-5 Questionnaire of Life Satisfaction

	Yes	No
Get a smoother life than other people	1	0
Satisfied with life	1	0
My life could be happier	1	0
I would not like to change my life if I could	1	0
These years are the best years in my life	1	0
Most things I do are boring	0	1
Interested in things which I have done	1	0
Expect pleasant things in the future	1	0
I feel old and somewhat tired	0	1
Most things are the same as my expectation in my life	1	0

Note: the number in the table is the score of response

Table A-6 Interval Regression 1989

Group	Working		Non-working	
	Coef.	Std	Coef.	Std
Sex	2013.233	(726.491)***	-1490.71078	(439.873)***
Age	-1723.785	(1202.820)	-1623.45042	(511.354)***
Age Squ.	10.097	(8.608)	10.34213	(3.563)***
Edu. Year	775.869	(114.203)***	640.65312	(60.242)***
Farmer	-1443.02	(1190.290)		
High skill Worker	10240.94	(3363.786)***		
Senior Manager	6576.856	(1691.838)***		
Clerk	8287.575	(2332.314)***		
Sales clerk	1809.391	(1795.268)		
Craftsman	1153.099	(1619.475)		
Semi-skill Worker	-193.214	(1510.209)		
Service	2179.95	(1265.587)*		
Marital Status				
Married	-474.744	(3381.818)	4734.039	(2283.951)**
Divorced	-3934.085	(3833.716)	-1556.362	(2340.622)
Widowed	-4388.701	(3427.470)	1031.539	(2281.297)
Region				
North	2377.499	(1373.114)*	2902.954	(530.560)***
Middle	-144.198	(1203.862)	1804.294	(511.408)***
South	-719.727	(1233.906)	2827.215	(536.000)***
No. of Children	65.05	(170.801)	149.274	(92.729)
Income Source				
From Children and relations	-692.782	(710.094)	-272.531	(604.218)
From Pension	2149.43	(1284.864)*	3741.221	(561.745)***
From Gain	11920.482	(2876.544)***	6984.424	(982.967)***
cons	78882.69	(41678.413)*	63584.875	(18436.379)***
N	967		2408	

Table A-7 Interval Regression 1996

Group	Working		Non-working	
	Coef.	Std	Coef.	Std
sex	-18235.69	(21365.115)	-53564.773	(13688.371)***
Age	-28546.59	(22367.795)	-29822.525	(10549.584)***
Age Squ.	177.698	(182.778)	198.122	(77.827)**
Edu. Year	30218.494	(4573.722)***	17675.448	(1753.999)***
Farmer	-12700.007	(29132.901)		
High skill Worker	215969.819	(58605.807)***		
Senior Manager	223502.226	(57215.526)***		
Clerk	59289.063	(49251.289)		
Sales clerk	26192.595	(46308.001)		
Craftsman	73213.628	(37370.357)*		
Semi-skill Worker	-4402.212	(30453.651)		
Service	23156.402	(32036.611)		
Marital Status				
Married	154496.179	(60268.586)**	53930.980	(25860.172)**
Divorced	65927.068	(80302.280)	-4851.654	(33420.738)
Widowed	40334.831	(65786.444)	-3596.146	(26686.401)
Region				
North	160665.600	(48327.423)***	68666.817	(19411.943)***
Middle	28501.447	(37279.625)	27282.182	(16144.820)*
South	60553.706	(38917.507)	61215.785	(18965.591)***
No. of Children	1455.235	(7322.508)	2617.644	(2930.179)
Income Source From Children and relations	-41297.926	(13158.402)***	-8516.926	(21737.701)
From Pension	-29123.671	(13586.273)**	22134.676	(12169.700)*
From Gain	56430.996	(16918.066)***	14837.925	(9349.783)
cons	1049505.415	(678719.277)	1147374.240	(351452.562)***
N	890		1862	

Table A-8 Sample statistics (1989 only)

	Farmer Group		Non-Farmer Worker Group		Manufacturing Worker Group	
	Treatment	Control 1	Control 2	Control 3	Control 2	Control 3
	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
Health Indicators						
SAH	0.347 (0.477)	0.394 (0.49)	0.367 (0.482)	0.465 (0.499)	0.36 (0.482)	0.472 (0.501)
CES-D	5.647 (4.198)	5.614 (4.169)	5.793 (4.446)	5.553 (4.088)	4.894 (4.082)	5.337 (4.26)
LS	6.291 (2.4)	6.538 (2.411)	6.058 (2.489)	6.296 (2.507)	6.064 (2.239)	5.994 (2.512)
Educational Dummy						
Illiteracy	0.525 (0.5)	0.404 (0.492)	0.471 (0.499)	0.271 (0.445)	0.388 (0.489)	0.258 (0.439)
Primary S.	0.428 (0.495)	0.555 (0.498)	0.366 (0.482)	0.463 (0.499)	0.455 (0.499)	0.621 (0.487)
Junior H.S.	0.031 (0.173)	0.031 (0.173)	0.074 (0.21)	0.121 (0.326)	0.103 (0.305)	0.093 (0.292)
Senior H.S.	0.012 (0.111)	0.007 (0.083)	0.048 (0.215)	0.077 (0.266)	0.042 (0.202)	0.016 (0.128)
University	0.002 (0.045)	0.003 (0.059)	0.038 (0.191)	0.068 (0.251)	0.012 (0.11)	0.011 (0.105)
Postgraduate	-	-	0.001 (0.039)	-	-	-
Marital Status Dummy						
Married	0.691 (0.462)	0.821 (0.383)	0.601 (0.49)	0.746 (0.436)	0.606 (0.49)	0.731 (0.445)
Divorce	0.019 (0.135)	-	0.032 (0.176)	0.042 (0.201)	0.067 (0.25)	0.071 (0.258)
Widow	0.28 (0.449)	0.171 (0.377)	0.325 (0.469)	0.157 (0.364)	0.267 (0.444)	0.132 (0.339)
Single	0.006 (0.078)	0.007 (0.083)	0.042 (0.202)	0.055 (0.228)	0.061 (0.239)	0.066 (0.249)

Age	69.54 (3.171)	62.16 (1.3)	68.97 (3.051)	62.03 (1.346)	68.91 (2.932)	61.98 (1.368)
Squire of age	4845.4 (422.2)	3865.7 (161.5)	4799.3 (424.8)	3849.3 (16.9)	4757 (408.1)	3843.8 (169.6)
Male	0.669 (0.471)	0.688 (0.464)	0.471 (0.499)	0.581 (0.494)	0.679 (0.468)	0.769 (0.422)
Family Scale Dummy						
1-4 people	0.387 (0.488)	0.445 (0.498)	0.47 (0.499)	0.517 (0.5)	0.467 (0.5)	0.478 (0.501)
5-10 people	0.535 (0.499)	0.476 (0.5)	0.472 (0.499)	0.43 (0.495)	0.491 (0.501)	0.456 (0.499)
Over 10 people	0.078 (0.269)	0.079 (0.27)	0.058 (0.234)	0.053 (0.224)	0.042 (0.202)	0.066 (0.249)
Regional Dummy						
North	0.113 (0.317)	0.89 (0.285)	0.335 (0.472)	0.359 (0.48)	0.388 (0.489)	0.407 (0.493)
Middle	0.414 (0.493)	0.455 (0.499)	0.315 (0.465)	0.282 (0.45)	0.321 (0.468)	0.264 (0.442)
South	0.364 (0.482)	0.37 (0.484)	0.283 (0.450)	0.289 (0.453)	0.248 (0.433)	0.258 (0.439)
East	0.109 (0.312)	0.086 (0.28)	0.067 (0.25)	0.07 (0.256)	0.042 (0.202)	0.071 (0.258)
Job Type Dummy						
Self-employed	0.309 (0.462)	0.479 (0.5)	0.087 (0.281)	0.119 (0.324)	0.03 (0.172)	0.055 (0.229)
Family Business	0.002 (0.045)	0.01 (0.101)	0.007 (0.082)	0.007 (0.086)	-	0.027 (0.164)
Employee	0.039 (0.194)	0.079 (0.271)	0.104 (0.305)	0.3 (0.458)	0.188 (0.392)	0.473 (0.501)
Retire	0.008 (0.09)	0.01 (0.101)	0.091 (0.288)	0.088 (0.283)	0.145 (0.354)	0.132 (0.339)
Others	0.642 (0.48)	0.421 (0.495)	0.711 (0.453)	0.485 (0.5)	0.636 (0.483)	0.313 (0.465)
No. of Children	5.549 (2.185)	5.19 (1.757)	4.319 (2.159)	4.397 (2.038)	4.558 (2.15)	4.167 (2.175)
Sample size	486	292	1345	1094	165	182

Sample statistics (1993 only) (continued)

	Farmer Group		Non-Farmer Worker Group		Manufacturing Worker Group	
	Treatment	Control 1	Control 2	Control 3	Control 2	Control 3
	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
Health Indicators						
SAH	0.402 (0.491)	0.241 (0.435)	0.433 (0.49)	0.477 (0.501)	0.391 (0.489)	0.517 (0.509)
CES-D	7.03 (5.206)	7.138 (3.777)	7.195 (5.176)	7.51 (4.757)	6.66 (5.532)	6.966 (4.204)
LS	-	-	-	-	-	-
Educational Dummy						
Illiteracy	0.437 (0.496)	0.483 (0.509)	0.359 (0.48)	0.237 (0.427)	0.326 (0.47)	0.138 (0.351)
Primary S.	0.517 (0.5)	0.483 (0.509)	0.418 (0.493)	0.538 (0.5)	0.533 (0.5)	0.759 (0.453)
Junior H.S.	0.037 (0.189)	-	0.105 (0.306)	0.115 (0.321)	0.11 (0.314)	0.103 (0.31)
Senior H.S.	0.01 (0.098)	-	0.061 (0.24)	0.058 (0.234)	0.026 (0.161)	-
University	-	0.034 (0.186)	0.057 (0.232)	0.051 (0.221)	0.004 (0.066)	-
Postgraduate	-	-	-	-	-	-
Marital Status Dummy						
Married	0.719 (0.45)	0.724 (0.455)	0.653 (0.47)	0.769 (0.423)	0.648 (0.479)	0.793 (0.412)
Divorce	0.006 (0.076)	-	0.011 (0.103)	0.026 (0.159)	0.009 (0.094)	0.034 (0.186)
Widow	0.267 (0.443)	0.276 (0.455)	0.291 (0.454)	0.16 (0.368)	0.278 (0.449)	0.138 (0.351)
Single	0.008 (0.088)	-	0.045 (0.208)	0.049 (0.208)	0.066 (0.249)	0.034 (0.186)

Age	69.35 (3.125)	64 (0)	69.03 (2.941)	64 (0)	68.75 (3.031)	64 (0)
Squire of age	4819.3 (436.2)	4096 (0)	4773.3 (409.1)	4096 (0)	4736.2 (421.7)	4096 (0)
Male	0.7 (0.459)	0.621 (0.494)	0.518 (0.5)	0.571 (0.497)	0.709 (0.455)	0.793 (0.412)
Family Scale Dummy						
1-4 people	0.485 (0.5)	0.483 (0.509)	0.509 (0.5)	0.481 (0.501)	0.463 (0.5)	0.414 (0.501)
5-10 people	0.46 (0.499)	0.483 (0.509)	0.455 (0.498)	0.481 (0.501)	0.498 (0.501)	0.586 (0.501)
Over 10 people	0.055 (0.227)	0.034 (0.186)	0.036 (0.18)	0.038 (0.193)	0.04 (0.196)	-
Regional Dummy						
North	0.094 (0.292)	0.069 (0.258)	0.325 (0.469)	0.282 (0.451)	0.343 (0.476)	0.552 (0.506)
Middle	0.444 (0.497)	0.448 (0.506)	0.318 (0.466)	0.276 (0.448)	0.322 (0.468)	0.172 (0.384)
South	0.364 (0.482)	0.379 (0.494)	0.289 (0.453)	0.34 (0.477)	0.273 (0.447)	0.207 (0.412)
East	0.097 (0.297)	0.103 (0.31)	0.068 (0.252)	0.096 (0.296)	0.062 (0.241)	0.069 (0.258)
Job Type Dummy						
Self-employed	0.327 (0.47)	0.413 (0.501)	0.077 (0.267)	0.096 (0.296)	0.062 (0.242)	0.069 (0.258)
Family Business	0.012 (0.108)	0.07 (0.258)	0.009 (0.097)	0.013 (0.113)	0.004 (0.067)	0.034 (0.186)
Employee	0.055 (0.227)	0.034 (0.186)	0.106 (0.308)	0.199 (0.4)	0.212 (0.41)	0.207 (0.412)
Retire	0.033 (0.179)	0.034 (0.186)	0.142 (0.35)	0.128 (0.335)	0.137 (0.345)	0.207 (0.412)
Others	0.573 (0.495)	0.448 (0.506)	0.665 (0.472)	0.564 (0.497)	0.584 (0.494)	0.483 (0.509)
No. of Children	5.355 (1.985)	4.448 (1.938)	4.504 (3.897)	4.853 (7.007)	4.066 (2.224)	4.276 (2.562)
Sample size	513	29	1583	156	227	29

Sample statistics (1996 only) (continued)

	Farmer Group		Non-Farmer Worker Group		Manufacturing Worker Group	
	Treatment	Control 1	Control 2	Control 3	Control 2	Control 3
	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
Health Indicators						
SAH	0.371 (0.484)	0.401 (0.491)	0.324 (0.468)	0.425 (0.494)	0.423 (0.499)	0.525 (0.5)
CES-D	6.756 (4.476)	7.346 (4.757)	7.865 (4.818)	7.033 (4.282)	7.481 (4.889)	6.319 (3.5)
LS	6.5 (2.488)	6.558 (2.372)	6.283 (2.622)	6.361 (2.492)	6.18 (2.561)	6.296 (2.375)
Educational Dummy						
Illiteracy	0.384 (0.488)	0.353 (0.479)	0.318 (0.46)	0.252 (0.434)	0.327 (0.474)	0.172 (0.378)
Primary S.	0.551 (0.499)	0.583 (0.494)	0.44 (0.497)	0.528 (0.499)	0.49 (0.505)	0.658 (0.475)
Junior H.S.	0.051 (0.22)	0.035 (0.184)	0.113 (0.316)	0.106 (0.308)	0.164 (0.373)	0.085 (0.279)
Senior H.S.	0.005 (0.068)	0.026 (0.16)	0.072 (0.259)	0.077 (0.267)	-	0.06 (0.248)
University	0.009 (0.096)	0.003 (0.054)	0.057 (0.231)	0.034 (0.183)	0.018 (0.135)	0.019 (0.136)
Postgraduate	-	-	-	0.002 (0.048)	-	-
Marital Status Dummy						
Married	0.81 (0.393)	0.857 (0.35)	0.656 (0.475)	0.84 (0.367)	0.709 (0.458)	0.89 (0.313)
Divorce	0.023 (0.151)	0.015 (0.12)	0.022 (0.145)	0.03 (0.171)	0.018 (0.135)	0.034 (0.183)
Widow	0.162 (0.369)	0.114 (0.318)	0.276 (0.447)	0.108 (0.31)	0.218 (0.419)	0.047 (0.212)
Single	0.005 (0.068)	0.015 (0.12)	0.047 (0.212)	0.022 (0.148)	0.055 (0.229)	0.028 (0.166)

Age	69.2 (2.819)	58.13 (3.872)	70.17 (2.82)	56.68 (4.153)	68.96 (2.236)	55.2 (3.736)
Squire of age	4797.1 (392.7)	3393.8 (447)	4931.3 (396.7)	3230.1 (473.1)	4760.9 (307.8)	3061 (419.6)
Male	0.75 (0.434)	0.569 (0.496)	0.559 (0.497)	0.468 (0.499)	0.655 (0.48)	0.734 (0.443)
Family Scale Dummy						
1-4 people	0.556 (0.498)	0.402 (0.491)	0.545 (0.498)	0.454 (0.498)	0.509 (0.505)	0.414 (0.493)
5-10 people	0.407 (0.492)	0.551 (0.498)	0.432 (0.495)	0.511 (0.5)	0.473 (0.504)	0.558 (0.497)
Over 10 people	0.037 (0.189)	0.047 (0.211)	0.023 (0.151)	0.035 (0.183)	0.018 (0.135)	0.028 (0.166)
Regional Dummy						
North	0.102 (0.303)	0.09 (0.287)	0.303 (0.46)	0.27 (0.444)	0.418 (0.498)	0.226 (0.419)
Middle	0.495 (0.501)	0.446 (0.498)	0.313 (0.464)	0.32 (0.469)	0.327 (0.474)	0.354 (0.479)
South	0.324 (0.469)	0.405 (0.492)	0.318 (0.466)	0.354 (0.478)	0.218 (0.417)	0.389 (0.488)
East	0.079 (0.27)	0.058 (0.235)	0.065 (0.247)	0.05 (0.218)	0.036 (0.189)	0.031 (0.175)
Job Type Dummy						
Self-employed	0.486 (0.501)	0.524 (0.5)	0.074 (0.262)	0.186 (0.388)	0.073 (0.262)	0.171 (0.377)
Family Business	0.023 (0.151)	0.018 (0.131)	0.011 (0.106)	0.016 (0.126)	0.018 (0.135)	0.025 (0.158)
Employee	0.056 (0.231)	0.061 (0.24)	0.082 (0.275)	0.276 (0.447)	0.581 (0.498)	0.778 (0.416)
Retire	0.019 (0.136)	0.009 (0.093)	0.153 (0.36)	0.028 (0.166)	0.036 (0.189)	0.003 (0.056)
Others	0.416 (0.494)	0.389 (0.488)	0.679 (0.467)	0.494 (0.5)	0.291 (0.458)	0.022 (0.148)
No. of Children	5.139 (1.974)	4.245 (1.609)	4.319 (2.159)	3.744 (1.513)	3.818 (2.118)	3.536 (1.371)
Sample size	216	343	1853	1698	55	319

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