All Work and No Play:
Pecuniary versus Non-Pecuniary factors in the Labour Supply of the Elderly

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Abstract: Given falling birth rates, ageing baby boomers approaching retirement age as well as a pension crisis in most advanced economies, understanding the characteristics of the labour supply function of the elderly have taken on a new significance. Even in developing countries, with labour surplus economies, this is a major issue as these poor countries try to build a pension scheme with at least a minimum amount of state provision for the elderly. What motivates retired people to enter or continue in the labour force is the focus of our analysis. We use panel data from Korea which is an interesting country since it transited from developing to developed economy status within the last few decades and therefore exhibits characteristics of both underdevelopment and economic advancement. The econometric methods include probit models of: pooled data; panel data with random effects; and 2SCML, to allow for possible endogeneity bias induced by the self-declared health status of the elderly. We stress the crucial importance of pecuniary and non-pecuniary factors in determining labour supply of the elderly. Contrary to expectations, non-pecuniary factors such as health status are crucial in the decision-making process of whether to work or not to work for the elderly.

Keywords: labour force participation of the retired, pension benefits, probit estimation, panel data, random effects, demographic factors, family background, health status, income, assets.

JEL Classification: J14, J26, J32, C23, C25

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1 Introduction

As ageing baby-boomers approach retirement age, their economic behaviour and the correspondingly enormous socio-economic impact that they might cause, have become an important research agenda. Many policy studies have stressed the necessity for older workers to stay in the labour force, particularly from the viewpoint of labour shortage and the fourth pillar[1] of the pension and social security system. Interestingly, the elderly seem to have, along with higher retirement expectancy, a strong willingness to work longer. About eight out of ten of the baby-boomers in USA expect to work during their retirement[2] and it is reflected in the recent reversal of the early retirement trend in USA. The labour force participation rate for male workers aged 60-64 in USA recovered to the level of the early 1980s, at the beginning of the 2000s, after the end of a long-run early retirement trend. Such reversal of trends has not only been witnessed in some developed countries but also in some developing countries, such as China and South Korea, where the concerns over population ageing are growing. In Appendix A, we give data for these trends in a number of major countries. There is clear evidence that since 2000, there has been a change in trend relative to the previous two decades.

This phenomenon has raised the questions about why older people work during their retirement and whether the trend will persist. Many studies have attempted to explain work after retirement by various hypotheses: public pension reforms, the shift of private pension schemes to defined contribution plans, the change in an economic structure from manufacturing to services, the change in taste for work among older workers, such as an increase of active older workers with higher education leading to higher participation in knowledge intensive sectors and so forth. However, no clear conclusion about the reason for the persistency of the trend has been established. There is no doubt that this persistency depends on cooperative actions among public and private sectors, employers and employees, and older and younger generations. A prerequisite for understanding the implications of this persistency would be an in-depth analysis of the determinants of work after retirement.

The fundamental distinction is that between 'work or play': whether pecuniary or non-pecuniary factors are the major determinant of the labour supply of the old. In addition, while existing studies have mainly focused on older workers' labour force participation in developed countries, little is known about this phenomenon in developing countries. A better

[1] The three traditional pillars are public pensions, occupational pensions and private pensions.
[2] American Association of Retired Persons (2004)

picture of older workers' labour supply could be obtained by scrutinising various experiences from developing countries as well as developed countries. Further, the provision of state pensions could be either complementary or substitute to familial support and personal labour income of the elderly. In the light of these three factors, work or play, impact of economic development and the existence of family or state provision, this paper attempts to analyse the determinants of the labour force participation of the retired.

The specific data set and case study that we use is that of Korea. Korea has a number of interesting features which makes it particularly appropriate for the issues to be studied. It transited from a developing country, to a newly industrialised country to a developed country in the last four decades. Thus, it exhibits some of the socio-economic characteristics of underdevelopment but also provides evidence as to how a developed society could potentially behave. During the period under study, public pension schemes under a fully fledged welfare state was not operational; yet, family ties which underpinned the ageing society in the past had begun to weaken. Therefore, we observe both elements of dependency on the state as well as requesting help from the extended family. The influence of pecuniary versus non-pecuniary factors can therefore be studied in this more complex framework.

Several hypotheses can be advanced to explain the determinants of the labour supply of the retired in Korea and which has implications for other countries particularly in the developing world. One possible hypothesis is that the retired might be expected to respond less to a pecuniary incentive to work, partly because the retired receive some state pension benefits that can provide for their basic needs. However, it can be argued that the incomplete social safety net and its relatively short history in Korea would lead the retired to put their priority on pecuniary incentives in their labour supply decision-making. An alternative hypothesis is that non-pecuniary factors, particularly health, may be a crucial determinant of their labour supply. The assumption behind this is that being elderly, the retired are likely to be more sensitive, than are younger individuals, to the condition of their health in deciding whether they will continue in the labour force. Another hypothesis is that they might use a poor state of health as a reason for exiting from the labour force; creating a "justification hypothesis". Accordingly, a self-assessed health status, might suffer from measurement error and unobserved random effects might affect work status and self-rated health status, in effect, creating endogeneity between those variables. This is relevant to the assessment of health status, as a major non-pecuniary factor, and its link with the labour force participation of the elderly in this study. Another important hypothesis is that the retired with a working spouse

are likely to participate in the labour force. One basic assumption behind this is that an individual's preference for leisure is interdependent with that of his/her spouse. However, it can be suggested that the responses of men and women to their spouse's work may differ and that gender differential may be important. A man may be more likely to be influenced by his spouse's work status, while the opposite is less likely to be the case (Gustman and Steinmeier, 2000; Coile, 2004). An alternative possibility is that those who live in rural areas are likely to be employed with their spouse's in the agricultural sector. This seems to be reasonable in countries where the elderly have high labour force participation rates in rural areas. This is potentially of major importance in developing countries.

On the grounds of the above hypotheses, the specific questions which we aim to answer are: 1) To what extent is the labour supply of the retired affected by pecuniary factors, such as income, assets, private pensions and expected pension-benefit wealth? 2) To what extent do the retired respond to health status, the most important non-pecuniary factor, compared to the pecuniary factors? 3) Do the retired tend to use health status as an excuse or justification for not working? 4) Does the labour supply of the retired tend to be affected by their spouse's work and do their decisions differ by gender? Finally: 5) does the labour supply of the retired have different patterns according to residential area, particularly in terms of the response to a spouse's work status? We use a random effects probit model on panel data for Korean households to conduct an empirical investigation to answer these questions. We then draw out policy implications.

The remainder of this paper is organised as follows. In Section 2, we contextualise the formal analysis by providing both, a brief survey of Korea's economic performance and demographic transition, as well as discussing the *macroeconomic* implications of demographic dividend and labour supply of older workers. Although the main thrust of the paper is to discuss the microeconomic determinants of labour supply, the macro model provides a contextual framework as to why the aggregate economy may wish to have its elderly continue to work. Section 3 discusses core methodology, theoretical structure and econometrics issues. Section 4 presents a sample selection and the construction of variables. In Section 5, the empirical model and results are discussed. Section 6 provides concluding remarks.

2 Contextual Issues

2.1 Macroeconomic justification for labour supply of the elderly

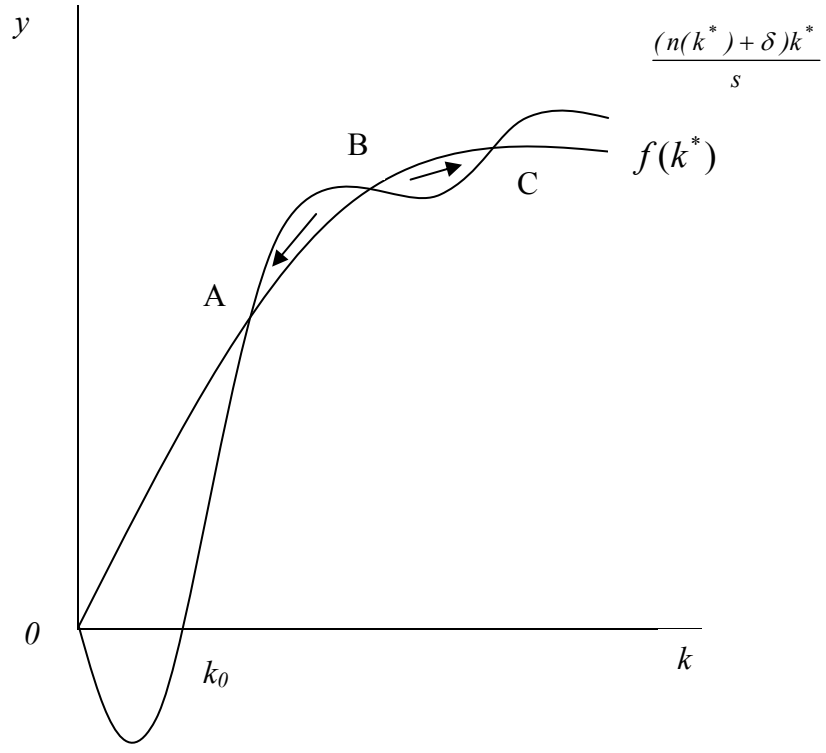
A prior question, before we embark on the detailed determinants of labour supply of the elderly would be the following: why does the aggregate economy need the old to work? We utilise a simple extension of the neoclassical growth model with endogenous population growth to answer this question. In the standard Solow growth model, population growth rate plus labour augmenting technological progress (the natural rate n) is considered constant. In an augmented version of the model, population plus augmentation is made a function of per capita income which in turn is dependent on the capital labour ratio (k). With $n = n(k)$. the demographic cycle could produce a natural rate of growth which declines (or becomes negative) at the early stages of development (see Nerlove and Raut, 1997) and then rises with capital accumulation, to become positive after capital stock crosses a threshold level of k_0.

Normally, we would expect this $n(k)$ function to exhibit diminishing returns after k_0. If this is so, then there exists the possibility of a multiple equilibrium with 0, A and B as the three possible equilibria in Figure 1. As is normal in such models, A in this case is the stable equilibrium, so that development once started will lead the economy from $k = 0$ to the level of steady state equilibrium at A. Any exogenous 'push' after that (for example through foreign aid), without changing core parameters like the savings ratio, will bring the economy back to A again.

Now consider the case where the labour supply of the elderly is utilised to increase the natural rate of growth upwards. This could be via increasing the effective rate of growth of labour supply or by utilising the human capital skills accumulated by the elderly to boost labour augmenting technical progress. Thus, as k increases, not only will n increase but the slope of the curve itself might be increasing upwards (in this range, $n' > 0$ and $n'' > 0$ too). This creates the possibility of a multiple equilibrium with three possible cases where $k > 0$. The adaptation of the neoclassical growth model, with a special role attached to the contribution of the elderly, is shown in Figure 1. The three steady state equilibrium points are A, B, C. 'A' is the (stable) low level or underdevelopment equilibrium; 'B' is point of (unstable) medium level development as say characterised by a newly industrialising country; 'C' is the (stable) high level developed economy equilibrium. The diagram fits well with our case study since Korea has effectively moved from points like A to B to C in recent decades. Indeed, this is an example of the celebrated 'Big Push' of early developmental literature (Rosenstein-Rodan, 1943).

Clearly, our growth parable could be used to explain any number of cases where the 'natural rate of growth' takes on the postulated shape to create the possibility of multiple equilibria. However, the employment of the elderly is particularly suitable for this growth story since they actually contribute directly to working population (labour supply) growth as well being able to increase technical progress through their past training and skill retention. Thus, we can justify that there are good growth-theoretic and macroeconomic reasons to use the labour force of the elderly to boost the natural rate of growth and create the possibility of a high level of growth and development. Essentially, using the labour of the elderly the economy in principle can potentially move from a low level steady state equilibrium to one with a higher level of capital accumulation, per capita income and steady state growth rate (*A* to *C*).

Figure 1 Multiple equilibrium in a neoclassical growth model with endogenous population



2.2 Economy and demography of Korea

Korea has experienced a remarkable economic performance in tandem with a rapid demographic transition for the last several decades. Its economic achievement is well represented by an average annual GDP growth rate of 6.7% between 1953 and 2007. Real GNI per capita also leapt to $14, 598 in 2007 from $844 in 1953 (at constant 2000 US $). The primary industry-oriented economy with shares of 48.4% in production in 1953 was transformed into a services-oriented economy within five decades (e.g. in 2007, Korea had 69.6% of services, 27.5% of manufacturing and 2.9% of primary industry). Korea was positioned as the fourteenth largest economy in the world in terms of the share of global GDP in 2005 (World Bank, 2008). As noted above, these changes can be mapped out from *A* to *B* to *C* in Figure 1.

What is noteworthy is that along with the shift, Korea has undergone a dramatic demographic transition. Propelled by a steep drop in total fertility rate from 6.33 in the second half of the 1950s to 1.25 in 2007, it resulted in the reshaping of age structure: The fraction of people aged 0-19 was more than halved from 52.4% in 1965 to 25.7% in 2005, even though people aged 65 and over showed an almost triple increase from 2.9% to 9.3% for the same period. In contrast, that of people aged 20-64 kept a steady increase to 65% in 2005 from 44.3% in 1965. It connotes a drastic reduction in potential economic burden of non-workers and a favourable environment for economic growth. In this regard, Korea's demographic transition has been suggested as an exemplary case study of the demographic 'dividend'.

However, during the next decades, Korea is projected to transform further, into an 'old' country with people aged 65 and over constituting more than one-third of population. Following the projection by the United Nations (2009), the ratio of those aged 65 and over to working-age population aged 20-64 is expected to almost quintuple: the number of elderly people per 100 workers is forecast to escalate from around 14 in 2005 to around 68 in 2050. The impact of such a sky-rocking increase in the number of old population per worker may be tremendous on Korean economy. Furthermore, it would intensify just as fledgling public pension schemes in Korea fully mature. As such, Korea is approaching a crossroads where it might either roll back from *C* to *B* to *A* in Figure 1, or keep track of a steady state growth. It requires appropriate measures for alleviating such potential burden.

One of the most effective measures may be found in the characteristics of the Korean labour market: old workers tend to stay longer in the labour force compared to those in other

countries (Appendix A). For the labour force participation rate of male age group 60-64, Korea is at the high level of 59% in 2005, behind Japan (70.3%), Sweden (65.5%) and Ireland (60%). Particularly, those aged 65 and over in Korea are at the highest level: in 2005, half of those aged 65-69 in Korea remained in the labour force. This sheds a light at the crossroads, suggesting that the maintenance of such high labour supply level would be one possible solution to the potential demographic 'disaster'.

3 Modelling the labour supply of the elderly

3.1 Theoretical framework and literature overview

Theoretically, it is expected that various economic and non-economic determinants, such as income, wealth, debt, pension provision, human capital, demographic characteristics and family background, should be incorporated into the labour supply equation of the retired so that:

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$$= f\ (\textit{demographic characteristics and family background, health, educational attainment, income, assets, investment in education, labour demand}) \quad (1)$$

Demographic characteristics and family background include age, position in household, the number of dependants, marital status and spouse's working status. The explanatory variables and their expected impact on the labour supply of the retired can be summarised in Table 1. It is anticipated that age, urban residence, income, expected pension wealth, assets, and the regional unemployment rate may reduce the disposition to work of the retired. It can be assumed that the positive impact on the willingness to work may come from being the household head, good health, educational attainment and educational expenditure. The others could go either way. These expectations are summarised in Table 1.

Age can be assumed to be negatively associated with the willingness to work. One possible explanation is that the marginal value of leisure is likely to increase with age due to a decrease in the remaining time to enjoy it (Parker and Rougier, 2007). Being the household head is supposed to increase the probability of working because the household head is the de facto representative of the household and accordingly is likely to have more responsibilities to care for family members; this would be particularly important in a developing country.

Table 1 The expected relationships between work status and the explanatory variables

Explanatory variables		Work Status
Demographic characteristics	Age	-
	Household head	+
	Dependants	-/+
	Spouse (with a job)	-/+
Health status and education	Good health	+
	Educational attainment	+
Income and assets	Income from other household	-
	Public and private pension	-
	Assets	-/+
	Debt	-/+
Expenditure	Educational expenditure	+
Labour demand	Regional unemployment rate	-

The number of dependants, children and other old adults, has been hypothesised to reduce the probability of working. It would be because caring responsibilities for dependants may prevent job-search or employment (Smeaton and McKay, 2003) or may increase the desire for leisure (Parker and Rougier, 2007). However, if pecuniary factors are dominant in decision-making, more financial responsibility would increase labour supply. Similarly, marriage may be supposed to increase the likelihood of work. One possible explanation is that it involves more responsibilities for the family. A different explanation is related to the spouse's work status. An individual with a working spouse may stop a paid job should the income from the spouse's employment be sufficient to support the household's needs. However, if leisure is a joint household good, consumption of leisure in the company of one's spouse would increase its benefit. One hypothesis is that having a spouse who has a job may lead to a higher likelihood of work. For instance, Blau (1998) and Gustman and Steinmeier (2000)[3] find that non-employment of a spouse induces an individual to exit out of the labour force, or that a spouse's retirement increases the value of leisure of the other spouse. This hypothesis of joint decision-making seems to favour a non-pecuniary explanation for the

[3] Blau (1998) uses 5,501 married couples from the Retirement History Survey in USA; Gustman and Steinmeier (2000) use 564 couples' data from the National Longitudinal Survey of Mature Women, 1968-1989.

elderly to work. Once again, a more pecuniary orientated model would put spouse retirement as an incentive to work more given the diminution of household incomes.

Poor health can be assumed to have a negative impact on the probability of work. The possible reasons for this are that poor health may i) reduce earnings or the ability to work, ii) accordingly lead to lower opportunity cost of leisure, iii) reduce the time available for work due to concern for health and induce early retirement if it shortens life expectancy (Dwyer and Mitchell, 1999; Disney et al., 2006). Particularly, the negative effect of health on labour force participation is likely to be evident as individuals are getting older (Bound, 1991; Benítez-Silva, 2000).

Regarding the role of health in labour supply of the elderly, two issues have been discussed; its measurement and its endogeneity. In general, information on health status tends to be based on the self-reported health status. As observed in Section I, one argument for this self-reported health status is that an individual who wants to stop a paid job may use health as an excuse and accordingly is likely to exaggerate a bad health condition, namely the justification hypothesis (Anderson and Burkhauser, 1985; Bazzoli, 1985; Kerkhofs et al., 1999). If so, self-reported health status may overestimate the impact of health on labour supply. In this regard, objective measures, such as functional limitations like physical disability and specific health problems such as circulatory disorders, may be an alternative to the subjective self-reported measure. However, it has also been suggested that the self-reported health measure is still reliable (Stern, 1989; Bound, 1991; Dwyer and Mitchell, 1999) and objective measures can also produce biased estimators (Bound, 1991). Meanwhile, this possible measurement error, as indicated by the justification hypothesis, can lead to the endogeneity bias of health. The health status reported by an individual may be incorrect for psychological reasons or financial reasons, such as pension benefits, and may be closely related to the decision whether to work or not (Stern, 1989). Other potential sources of the endogeneity of the health variable are unobserved individual random effects, such as habits or preferences, i.e. the preference for work may be related to that of good health (Anderson and Burkhauser, 1985). At the same time, work itself can affect health. For example, the lack of activity may lead to bad health and vice versa (Anderson and Burkhauser, 1985; Kerkhofs et al., 1999). The possible solutions to these empirical issues are discussed in the next section.

Most empirical results seem to support the negative association between poor health and the probability of work (Bound, 1991; Blau, 1994; Dwyer and Mitchell, 1999; Benitez-Silva, 2000; Haider and Loughran, 2001; Smeaton and McKay, 2003; Disney et al., 2006).

However, Bazzoli (1985) argues[4] that pecuniary variables, such as pension entitlement and real wage, are more crucial determinants of retirement than health. One possible explanation for this is that individuals tend to report poorer health after retirement, namely the justification hypothesis, and accordingly the correction of this bias, such as by using previous objective health measures, can lead to a smaller impact of health on retirement.

Educational attainment, such as the number of years of schooling, is expected to increase the probability that an individual will work in retirement. Some possible explanations for this can be suggested: education may positively affect the preference for work (Blau, 1994; Blau and Goodstein, 2006); a high level of education can provide various job opportunities for the elderly (Yamada and Yamada, 1988), such as more desirable job offers with better working conditions; higher education is associated with higher earnings indicating higher opportunity cost of retirement. Accordingly, education may increase the years of labour force participation (Yamada and Yamada, 1988).

However, empirical results have been inconclusive. Haider and Loughran (2001)[5], show that a higher level of education is associated with higher LFPR. Blau and Goodstein (2006) attribute the increase in the LFPR of older men in the United States to the increase in the proportion of older men with high school degrees in the labour force. In contrast, some studies have suggested that the impact of education on the labour supply is small (Blau, 1994) and is rarely significant (Benítez-Silva, 2000). One possible explanation is that education may affect the labour supply through indirect channels, such as wage and tenure, and accordingly the inclusion of indirect channels into the model can result in an insignificant coefficient of education (Benítez-Silva, 2000). Another possibility is that individuals with a high level of education can prepare for their retirement with high earnings before their retirement, and accordingly they are likely to have no necessity to work in old age.

It is clear that financial resources, including income, assets and debt, play a significant role in the labour supply decision. However, even here the distinction between pecuniary and non-pecuniary issues could become crucial. Labour force participation can be assumed to be a function of the price of retirement, that is to say the earnings rate or the level of earnings. One problem to be faced at the micro level analysis is that the earnings of people who are not working are not observed. Accordingly, if the wage rate is simply employed as an explanatory variable, it can lead to self-selection bias because working pensioners are not

[4] Using data from the Longitudinal Retirement History Survey in USA from 1969 to 1975
[5] They use data from the Current Population Survey in USA for the period 1991-1999.

representatives of all pensioners. As a result, it may result in a failure to make a good prediction of labour force participation of the retired. One of the solutions to deal with this problem is to obtain the predicted wages for all individuals from wage estimation using data on individuals with a job and then to use the predicted wages at the second stage estimation (Killingsworth and Heckman, 1986). Another possible solution would be to exclude wage rates from the explanatory variables and instead include variables which may be determinants of the wage rate (Ettner, 1995). This method is also used by Sasaki (2002), insisting that if the expected wage rate depends on the other determinants of labour force participation, the inclusion of the expected wage rate into the labour supply equation may suffer from an identification problem. The latter approach is also a simple way to handle the endogeneity problem of joint decision about labour force participation and the wage rate. As we see later, the latter approach is used in this study by not including the wage rate directly in the set of explanatory variables.

The standard labour supply model indicates that if leisure is a normal good, non-labour income is negatively associated with the disposition to work. If a positive association between non-labour income and labour force participation is detected, it may be caused by 'taste for work', which indicates that some people have a tendency to work more (Borjas, 1996). The general concept of non-labour income tends to cover various forms of unearned income, such as interest on deposits, stock dividends, housing rent, land lease fees, social insurance benefits, transferred income and so on. Among them, Quinn (1977) points out that what needs to be included is the potential amount of social security and pension benefits rather than the actual amount of social security and pension benefits. He explains that the second can depend on labour force participation and accordingly induce an endogeneity bias. Although we follow Quinn's (1977) suggestion, we do not use a simple possible benefits flow but the expected pension wealth as an explanatory variable, which is obtained by summing up the present values of these simple cash flows over a lifetime. The reason is that considering both current income and future income may produce a better prediction on labour force participation in terms of the life-cycle hypothesis. It has the further advantage of offering potential insights into the effect of the pension wealth on labour force participation of the retired. Pension wealth may induce workers to leave a job. For example, Rust and Phelan (1997), using the data from the Retirement History Survey, find that social security benefits can create disincentives to labour force participation. However, other studies also argue that the effect of pension wealth is not substantial and both pension wealth and other

factors, such as health and wealth, may explain labour supply. We consider both private pension wealth as well as public pension wealth. It is partly because some studies have emphasised the role of private pensions schemes as well as public pension in the labour supply (Ippolito, 1990; Johnson, 2002; Blau and Goodstein, 2006)[6].

Apart from the expected pension benefits, assets including real estate and liquid assets are employed as indicators of the socioeconomic status of individuals. In general, it can be assumed that assets increase the probability of leaving the labour force. For example, Doling and Horsewood (2003) find that home ownership causes male workers over the age of 55 to retire early in 19 European countries in the 1990s. In contrast, Haider and Loughran (2001) suggest a positive association between labour force participation and assets. They state that relatively wealthier individuals may have a tendency to stay in the labour force longer. That is confirmed by Ozawa and Lum (2005), using data from 1993 Asset and Health Dynamics of the Oldest Old Study in the United States. One possible explanation is that relatively wealthier individuals can have access to agreeable working conditions and enjoy work in old age. Non-pecuniary factors may dominate wealth effects. Debt may also affect the labour supply of the retired. It may induce the retired to leave the labour force but may not be a barrier to moving into work (Kempson et al., 2004). What is to be noted is that pensioners are likely to hold physical assets, such as a house, which can be collateral for borrowing. If so, growing debt may be associated with lower labour force participation, since assets and income are substitutable.

In addition to the above supply factors that affect labour force participation, the disposition to work may be influenced by the labour demand factors (Smeaton and McKay, 2003; Schmidt and Sevak, 2006). These labour demand factors can be approximated by regional unemployment levels or regional industry structure. For example, if the regional unemployment rate rises, it is expected that the elderly, such as pensioners, are more likely to leave a job and their chances of being employed are likely to fall. Additionally, regional unemployment rate partly reflects the region of residence. Considering the relatively high LFPR in rural areas in Korea, the region of residence could be included as an explanatory variable. However, it would cause multicolinearity between the region of residence and the

[6] Defined Benefit pension plans, whose benefits depend on retirement age, tenure and average earnings, may induce individuals to leave the job when their expected benefits are high. In contrast, the Defined Contribution pension plans may not produce disincentive for working at older age because their benefits are a function of contributions and the returns on the contributions.

regional unemployment rate. For these reasons, only the regional unemployment rate is incorporated into this study.

3.2 Econometric Methodology

3.2.1 General considerations: Panel data, individual specific effects, logit and probit models

Since the dependent variable in equation (1) is unobserved, being the disposition to work, it has to be proxied by a dummy variable which indicates whether any given individual in the sample is in work (dummy is assigned the value 1) or not (the dummy being assigned the value 0). Hence, the statistical estimation of the equation requires the use of logit or probit models; the optimum data structure of which might be panel or pooled. In general panel data format equation (1) is:

$$Y_{it} = \alpha + X'_{it}\beta + \mu_i + \varepsilon_{it} \qquad i = 1,\cdots,N,\ t = 1,\cdots,T \tag{2}$$

Here Y_{it} is the dummy variable, α is a constant, X'_{it} is the row vector of regressors, β is the associated parameter vector, μ_i represents unobserved individual specific effects, ε_{it} are error terms for individuals with $\varepsilon_{it} \sim IID(0,\sigma_\varepsilon^2)$, N is the number of individuals and T is the number of observations.

The assumption about the individual specific effects, of course, determines whether the model is estimated by assuming they are fixed or random effects. Each of those assumptions generates its own well-established difficulties. Thus, for example, should we assume that the effects are fixed then the number of parameters involved in the estimation of equation (2) increases by N. This can produce the incidental parameters problem: an inconsistent estimator of the β vector. Of course, in linear panel models, that can be circumvented by, amongst other things, taking differences of the variables; however, in nonlinear models the inconsistency can remain (Chamberlain, 1980). He suggests a method by which that inconsistency can be overcome; but the method only succeeds for the logit and not for the probit model (Greene, 2003).[7]

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[7] Chamberlain (1980) suggests that for the logit model, individual specific effects (μ_i) can be removed by maximizing the following likelihood function conditional on a sufficient statistic for μ_i , that is $\sum_{t=1}^{T} Y_{it}$.

$$L_C = \prod_{i=1}^{N} Pr(Y_{it},\cdots,Y_{iT} \Big/ \sum_{t=1}^{T} Y_{it})$$

In a random effects model, individual specific effects μ_i are treated as randomly distributed (with a mean of zero and a variance of σ_μ^2) and independent of both ε_{it} (mean of 0 and a variance of 1) and X_{it}'. Then, letting $\nu_{it} = \mu_i + \varepsilon_{it}$: $Var[\nu_{it} \mid X_{it}^{'}] = \sigma_\mu^2 + 1$, $Corr[\nu_{it}, \nu_{is} \mid X_{it}^{'}] = \rho = \sigma_\mu^2 / (\sigma_\mu^2 + 1)$, so the joint probability for all T_i observations can be written as: $L_i = P(Y_{i1}, \cdots, Y_{iT_i} \mid X) = \int_{L_{iT_i}}^{U_{iT_i}} \cdots \int_{L_{i_1}}^{U_{i1}} f(\nu_{i1}, \cdots, \nu_{iT_i}) d\nu_{i1} d\nu_{i2} \cdots d\nu_{iT_i}$

Therefore, the random effects model requires computing the joint probabilities of a *T*-variate normal distribution, that is to say *T*-dimensional integrals. These *T*-dimensional integrals are impractical in most cases, but they can be reduced to a single integral by conditioning on the individual effects (see Greene, 2003). Butler and Moffitt (1982) suggest that this integral can be evaluated with the Gaussian quadrature procedure[8]. This method has the advantage that a random effects model can be estimated even for large *T* (Baltagi, 2001; Greene, 2003). However, it embodies the strong assumption of identical correlation between successive disturbances of the same individual. A further problem is that as the panel size increases, the change of quadrature points can affect the estimation results and accordingly quadrature approximation can become less accurate. One way to handle this problem is to check relative differences between coefficients with the increase in the number of quadrature points. Generally speaking, if the coefficients do not change by more than a relative difference of 0.01%, the estimation results may be acceptable (Stata, 2005).

Of course, when testing whether individual specific effects of a given kind, fixed or random, are embodied in the data, two models have to be estimated. One approach is to compare the pooled estimator with the panel estimator by testing $\rho = \sigma_\mu^2 / (\sigma_\mu^2 + 1) = 0$ (Stata, 2005). If $\rho = 0$, this implies that $\sigma_\mu^2 = 0$, so that the panel-level variance component is unimportant and accordingly, the panel estimator does not differ from the pooled estimator.

The conditional density for $Y_{it}, \cdots, Y_{iT}$, conditional on $\sum_{t=1}^{T} Y_{it}$ does not depend on μ_i (see Chamberlain,1980; Baltagi, 2001). Hence, this conditional distribution is the same for all parameter values and accordingly $\sum_{t=1}^{T} Y_{it}$ is called a sufficient statistic.

[8] A *n*-point Gaussian quadrature procedure is to get the definite integral of a function as a weighted sum of function values at specified points by choosing appropriate weights for the function to be approximated by a polynomials of degree up to *(2n-1)*. For example, it is to choose w_k and x_k to in the equation of $\int_{-1}^{1} f(x)dx = \int_{-1}^{1} W(x)p(x)dx = \sum_{k=1}^{n} w_k f(x) = \sum_{k=1}^{n} w_k p(x_k)$ given the weighted function, such as Gauss-Hermite function $(W(x) = e^{-x^2})$.

Hence, the likelihood-ratio test[9] can be employed to examine whether panel model estimation is appropriate. An alternative method may be a Hausman test based on the differences between an unconditional maximum likelihood estimator and a conditional maximum likelihood estimator (Baltagi, 2001; Greene, 2003). Regarding this issue, Maddala (1987) suggests that a pooled model can also give consistent estimators of β.

Hence, we first estimate a pooled model. Its results are then compared with the results from the estimates from a panel model. Thereafter tests for the existence of individual specific effects are conducted. However, in contrast to the linear panel regression models, there is no method in nonlinear models by which to evaluate which is better, a fixed effects model or a random effects model (Greene, 2003). Following the suggestion by Maddala (1987), a logit panel model is appropriate for a fixed effects model because a probit panel model estimator is not consistent in the fixed effects model. A probit panel model is preferred for a random effects model. We note, however, that when the error terms are heteroskedastic, estimations can be inconsistent. At the same time, the existence of unobserved individual effects makes $Y_{i1},\cdots,Y_{iT}$ be dependent conditional on X_{it}. Hence, for robust inference, standard errors need to be adjusted. To do this, a bootstrapping procedure[10] is used in this study.

3.2.2 Possible endogeneity bias and estimation procedures

One concern about equation (2) is the possible endogeneity of some explanatory variables. Since one such variable is the wage rate it is excluded from the estimation. Another potential endogenous explanatory variable may be health status, as noted in the Introduction, which existing studies have attempted to overcome by a variety of devices such as: (i) using objective health measures, such as functional limitation, measured by physical disability and difficulties in outdoor activities, rather than self-assessed health status (Dwyer and Mitchell, 1999); (ii) including both self-assessed health status and objective health measures (Kalwij and Vermeulen, 2008); and, (iii) instrumenting the self-rated health status by the predicted health status which is obtained by using objective health measures and individual characteristics, like drinking and smoking (Kerkhofs et al., 1999; Disney et al., 2006). The

[9] The test being whether the estimated variance component is different from zero: so the test is based on the boundary of the parameter space. Hence, the LR statistic is not the usual χ^2 statistic with one degree of freedom (Stata, 2005).

[10] It implies that the repeated random drawing from the original dataset produces replicated statistics which is a basis of the calculation of standard errors. Even though the accuracy of estimates depends on the replication of procedure, the acceptable estimates of standard errors can be obtained with 50-200 replications (Efron, 1981; Stata, 2005).

first two approaches, using objective health measures, may still suffer from endogeneity bias because they ignore the interactions between health and work. Consequently, we endeavour to overcome this problem by adopting the third approach.

Many approaches have been advanced to correct that potential bias in cross-sectional estimation, such as the generalized two-stage probit estimation of Amemiya (1978) and the two-stage conditional maximum likelihood estimation (hereafter 2SCML) of Rivers and Vuong (1988). Rivers and Vuong's method is to use the reduced form residuals at the first-stage estimation as an additional explanatory variable in the second-stage estimation. That method has been extended to a panel data setting by Vella and Verbeek (1999) and Arendt (2002) and its acceptable performance is evidenced by the Monte Carlo experiments of Arendt (2002).

The 2SCML estimation has the advantage of providing a convenient means to determine whether or not the potential endogenous explanatory variables are to be so regarded rather than being exogenous. According to Arendt (2002), in the case of time-invariant explanatory variables, the 2SCML procedure is as follows.[11] An initial set of equations following equation (2) is formulated as follows, where the definitions for equation (2) hold except for that of R_t the potentially endogenous variable and the notation X'_{1it} for vector of the remaining possible determinants of the latent variable:

$$Y_{it} = \alpha + X'_{1it}\beta + R'_{it}\gamma + \mu_i + \varepsilon_{it} \tag{3}$$

where $R_{it} = \delta + Z'_{it}\varphi + V_{it}$ (4)

δ is a constant, Z_{it} is the row vector of instruments, φ is the associated parameter vectors, μ_i represents unobserved individual specific effects, ε_{it} are error terms for individuals, Y_{it} is the observable work status and Z_{it} is the instrument sets. If the conditional mean of μ_i is a linear function of V_i, that is $E(\mu_i \mid V_i) = \psi V_i$, individual random effects are,

$$\mu_i = \psi V_i + \upsilon_i \tag{5}$$

Substituting this into equation (3),

$$Y_{it} = \alpha + X'_{1it}\beta + R'_{it}\gamma + \psi V_i + \upsilon_i + \varepsilon_{it} \tag{6}$$

[11] Vella and Verbeek (1999) and Arendt (2002) have in comon in two points: a random effects model is assumed and an endogenous explanatory variable is a continuous variable. However, they have two differences. First, the assumption of an endogenous explanatory variable differs. While the first attempts to handle the endogeneity of time-variant explanatory variables, the second assumes the endogeneity of time-invariant explanatory variables. Second, regarding a structure for the random effects, the former does not have its additional assumption, the latter has an explicit assumption about it, as shown in equation (5).

As such, 2SCLM can be implemented in two stages. First, estimate equation (4) by maximizing the marginal log likelihood and then the residuals (V_i) are obtained. They are included in equation (6) the log likelihood of which is then maximized. The test of the exogeneity of the potential explanatory endogenous variable is conducted by examining the significance of ψ.

The foregoing has assumed that R_i is a continuous variable. However, it can be a binary variable. The test for exogeneity of R_{it}^* can be conducted in a similar way as 2SCML (Wooldridge, 2002). The predicted residuals in the binary version of equation (4) can be calculated as the generalised residuals following Gourieroux et al. (1987):

$$\begin{aligned}\hat{V}_{it} &= E(V_{it} \mid R_{it}) = \frac{\Xi(\delta + Z_{it}'\hat{\varphi})}{\Phi(\delta + Z_{it}'\hat{\varphi})[1-\Phi(\delta + Z_{it}'\hat{\varphi})]}[R_{it} - \Phi(\delta + Z_{it}'\hat{\varphi})] \\ &= \Xi(\delta + Z_{it}'\hat{\varphi})R_{it}\left\{\frac{\Phi(\delta + Z_{it}'\hat{\varphi}) + [1-\Phi(\delta + Z_{it}'\hat{\varphi})]}{\Phi(\delta + Z_{it}'\hat{\varphi})[1-\Phi(\delta + Z_{it}'\hat{\varphi})]}\right\} - \frac{\Xi(\delta + Z_{it}'\hat{\varphi})}{[1-\Phi(\delta + Z_{it}'\hat{\varphi})]} \\ &= \frac{\Xi(\delta + Z_{it}'\hat{\varphi})}{\Phi(\delta + Z_{it}'\hat{\varphi})}R_{it} - (1-R_{it})\frac{\Xi(\delta + Z_{it}'\hat{\varphi})}{[1-\Phi(\delta + Z_{it}'\hat{\varphi})]}\end{aligned} \tag{7}$$

where $\Xi(\cdot)$ and $\Phi(\cdot)$ are the probability density function and the cumulative distribution function of $N(0,1)$, respectively.

However, in the case of a binary variable, the two-step approach using the predicted probabilities from the first-stage estimation may not produce consistent estimators (Wooldridge, 2002). One possible solution to avoid this problem is to use a full maximum likelihood approach with a joint distribution of (Y_{it}, R_{it}) (Wooldridge, 2002). An alternative method is Mallar's (1977) two-stage procedure. His two stage procedure is to i) obtain the predicted index, $R_{it}^* == \delta + Z_{it}'\hat{\varphi}$, rather than the predicted probabilities at the first stage and ii) to substitute it for R_{it}^* at the second stage. When the measurement error of R_{it} is suspected, this approach has a further advantage of the explicit correction of the measurement error. The reason is that the predicted index from the first-stage estimation is used at the second-stage estimation. As discussed above, if the self-rated health status suffers from a measurement error, the predicted health status from the first stage estimation can be used to correct this possible measurement error. This approach is in line with Kerkhofs et al. (1999) and Disney et al. (2006). For this reason, the Mallar's approach is used in this study.

This two-stage approach in the estimation requires the correction of covariance matrices because using the predicted values from the first-stage estimation introduces

heteroskedasticity at the second stage estimation (Lee et al., 1980). Hence, in practice, all standard errors in the second stage estimation are adjusted by using a bootstrapping procedure. As with the linear simultaneous equation estimation, the order condition for identification requires that the number of instrument variables is at least as great as the number of endogenous explanatory variables.

3.2.3 Estimation strategy in Sum

The estimations upon which the remainder of the paper are based were conducted in the following sequence. First, following Maddala's suggestion, a pooled probit estimation is performed without considering individual specific effects. With this estimation result, equation (2) was estimated with a random effects probit panel model, checking the accuracy of the quadrature approximation and adjusting standard errors through a bootstrapping procedure for robust inference. Afterwards, the presence of individual specific effects was examined by using a likelihood ratio test for the panel-level variance component and a Hausman test. When the individual specific effects were significant, a random effects probit estimation was used to examine the roles of explanatory variables in labour force participation by calculating their marginal effects (which at the average values of the variables can be interpreted perhaps as those for the average individual).

To evaluate the possibility of endogenous bias, first, the exogeneity test for the self-assessed health status was conducted by using 2SCML estimation. When the self-assessed health status is found to be an endogenous explanatory variable, Mallar's two-stage estimators were used to investigate the determinants of the labour force participation. That result was compared with that from the random effects probit model to evaluate the presence of endogenous bias.

4 Sample and Construction of Variables

4.1 Sample

The data are from the Korean Labor and Income Panel Study (hereafter KLIPS)[12]. The sample periods are from 2000 to 2005 due to some variables. For example, information on

[12] The KLIPS, which the Korea Labor Institute has conducted every year since 1998, is a longitudinal survey of households in cities, sub-districts and towns, and their members aged 15 and over. The original households and their members were 5,000 and 13,321 in 1998 respectively. The retention rate of the original 5,000 households amounts to 77.8% up to the 9th wave of 2006. The KLIPS covers an extensive range of data on socio-economic status of households and individuals like other well-known panel studies, such as the Panel

private pension is available from 2000. Over the above sample period, the cases with missing values in crucial variables are excluded. Those who received lump-sum benefits are not included because in the labour supply, they are expected to differ from other pensioners who receive benefits on a monthly basis. As a result, the final sample is an unbalanced panel of 1684 observations on 678 pensioners.

They are under the National Pension Scheme (hereafter NPS) (75.5%) and Special occupational pension schemes (24.5%) (Appendix B). One possible argument for the sample is related to disability pensioners. Disability pension benefit drawers may have different labour supply patterns compared to other pensioners. However, on average, their Labour force participation rate (hereafter LFPR) (32.9%), which is defined as the ratio of workers to members in the group, is higher than the LFPR of the special occupational pensioners (23.7%). That might imply that labour force participation does not depend on the type of pension benefits but on other factors, such as the amount of pension benefits. Moreover, the general features of disability pensioners can be incorporated into the framework of this study, through the health status variable. For example, the probability that they are in excellent or very good health (12.3%) or in good health (13.7%) is below the average levels, 33.9% and 34.6%, respectively. For these reasons, disability pensioners are included in the sample. Individuals aged 50 or over compose 95.8% in total observations and the proportion of people aged 60-64 and 65-69 in total observations amount to 38.8% and 26.6% respectively (Appendix C). The proportion of pensioners residing in rural areas amounts to 56.7% (Appendix D). Males consist of 70.8% of all pensioners and 54.9% of males live in rural areas.

4.2 Construction of Variables

As specified in Table 2, the dependent variable is represented by WORK and is assigned value of '1' if an individual is in work and '0' otherwise. Among explanatory variables, a household head (HEAD) and a spouse with a job (SP_WORK) are all dummy variables. The number of dependants is separately considered as the number of children below age of 15 (CHILD) and the number of the elderly aged 65 and over (OLD). If the individual is more than 65 years old, the latter is calculated as the number of elderly aged 65 and over less one.

Study of Income Dynamics of the United States, the British Household Panel Study and the German Socio-Economic Panel.

Table 2 Definition and measurement of variables

Variable	Definition and measurement
Dependent variable	
WORK	work status, 1 if an individual has a job, 0 otherwise
Independent variable	
Demography	
AGE	age, continuous
HEAD	household head, 1 if an individual is household head, 0 otherwise
CHILD	the number of children below age of 15 in a household, continuous
OLD	the number of the elderly aged 65 and over except the individual aged 65 and over, continuous
SP_WORK	marital status, 1 if a spouse has a job, 0 otherwise
Health status and education	
HEALTH	health status, 1 if it is excellent, very good or good, 0 otherwise
SCHOOL	the number of years of schooling, continuous
Income and assets	
LAB_OTH	household earned income except the individual's earned income
INC_OTH	household income except the individual's pension benefits and household earned income
REAL	household real assets, continuous
FIN	household financial assets, continuous
DEBT	household debt, continuous
PRIVATE	the present value of personal pension, continuous
PENSION	the expected public pension wealth, continuous
Expenditure	
EDUPC	household expenditure on education per capita, continuous
Labour demand	
UNEMP	regional unemployment rate, continuous

Health status (HEALTH) is represented by a self-assessed indicator because the objective health measures, such as functional limitation, are available from 2003. It is a

subjective reply to a question on whether an individual is in excellent, very good, good, fair or poor health. HEALTH has a value of 1, if an individual is in excellent, very good or good health[13]. Education (SCHOOL) reflects the number of years of schooling.

Turning to income and assets, most are measured at the household level. Their nominal values are transformed into real values with CPI (2005=100). As mentioned in the previous section, due to the endogeneity problem and the sample selection problem, income consists of all types of income except a specific individual own-earned income and own-pension benefits. It is categorized into two types. LAB_INC indicates earned income of other household members. INC_OTH covers financial income such as interest on deposit and stock dividend, real estate income such as housing rent and land lease fees, social insurance benefits except the individual's pension benefits, transferred income such as unconditional aid received from the government and so on. The value of the real asset (REAL) is the sum of the current house of residence, building, land and other properties[14]. Financial assets (FIN) consist of savings in bank, stock, bond, trust, insurance, private mutual financing loan club and so on. Debt (DEBT) includes debt from banks and non-banks, borrowing from private sources and so on. Apart from current income, expected incomes are represented by personal pension wealth (PRIVATE) and public pension wealth (PENSION). They are constructed through more complicated procedures (Appendix E). In short, PRIVATE is calculated as the present value of the total amount which was paid into a personal pension scheme over the sample period. On the basis of Feldstein (1974), public pension wealth (PENSION) is derived as the actuarially discounted present value of future benefits. Household expenditure on education per capita (EDUPC) is obtained by dividing household educational expenditure by the number of household members. Regional unemployment rates (UNEMP) come from the Korea National Statistical Office (hereafter KNSO).

The descriptive statistics of the variables is given in Appendix F. On average, those individuals around 64 years of age with around 9 years of education have around 43% probability of labour force participation. The probability of work remains stable at that level over the sample period. They have additional monthly income of around 1.4 million Kwon (hereafter Korea Won) from other sources, real assets of around 180 million Kwon as the

[13] The question about health status is not included in 2002. Hence, the health status in 2002 is recalculated from the answers to the question about comparing the current health status with the last year's health status in 2003.

[14] In the KLIPS, those who are not aware of the market value of real assets are requested to respond in intervals. For convenience, the values of these cases are approximated by the median values of the intervals. Its possible measurement error is examined later.

dominant form of asset holdings and the expected public pension wealth of around 108 million Kwon as the first pillar of retirement income. Around 8 out of 10 individuals may be household heads. On average, the number of dependants residing with pensioners is small, indicating that the majority of individuals have no children below the age of 15 and around half of the individuals do not live with people aged 65 and over. Around 2 out of 10 individuals have a spouse with a job. Around 7 out of 10 are in excellent, very good or good health.

5 Empirical results

The results reported here then are derived basically from a random effects probit model; and we have controlled for possible measurement error or possible endogeneity bias, by means of a two stage panel probit model. As a summary of our findings we note now that: 1) Non-pecuniary factors rather than pecuniary factors tend to have more substantial impact on the disposition to work of the retired. 2) Even when its endogeneity is considered, health status holds its significant role in the labour supply of the retired. For example, if an individual is in good health, the probability that he/she will be in work as a retired person increases by around 36.7%. 3) As expected, the earned income of other household members, financial wealth and expected public pension wealth have negative effects on the labour supply of the retired, but a weak impact compared to non-pecuniary factors. 4) Having a spouse who has a job is shown to be the most significant contributor to the labour supply of the retired. Particularly, men have a statistically significant response to their spouses' work status. Finally, 5) the retired who reside in rural areas seem to respond positively to a spouse's work status, while those living in urban areas are not so affected.

We present and discuss the models that produced those findings in Sections 5.1, and 5.2.1-5.2.4. The most general pooled probit model is contained in Section 5.1 and is evaluated against the model where allowance is made for random effects. In Section 5.2, we consider issues relating to the specification and measurement of some of the explanatory variables used in Section 5.1. As a consequence, in sub-sections 5.2.1-5.2.4, we provide what we label Robust Tests, and these are for: self-rated health status; spouse's work status; respondent's gender and place of residence; and, the measurement of real assets, where the measure we have detailed in Section 4 is replaced by a dummy variable based on whether the specific household unit possesses its own property.

5.1 Pooled probit estimation without and with random effects

In full, the basic equation is:

$$\begin{aligned} WORK_t = {} & \alpha + \beta_1 AGE_t + \beta_2 HEAD_t + \beta_3 CHILD_t + \beta_4 OLD_t + \beta_5 SP_WORK_t \\ & + \beta_6 HEALTH_t + \beta_7 SCHOOL_t + \beta_8 LAB_OTH_t + \beta_9 INC_OTH_t \\ & + \beta_{10} REAL_t + \beta_{11} FIN_t + \beta_{12} DEBT_t + \beta_{13} PRIVATE_t + \beta_{14} PENSION_t \\ & + \beta_{15} EDUPC_t + \beta_{16} UNEMP_t + \nu_t \end{aligned} \tag{8}$$

In the sense that observations are not independent, a pooled probit estimation is conducted under the assumption of independence between individuals. Then, in order to consider individual heterogeneity effects, a random effects probit estimation was performed by replacing ν_t by $\mu_i + \varepsilon_{it}$. In estimation, the number of quadrature points was increased to obtain stable coefficients; and at 44 quadrature points, most of the relative differences of the regressors were at or under the level of 0.01%, suggesting that the estimated results are acceptable. The standard errors were obtained by using the bootstrapping procedure with 200 replications.

The estimates are given in Table 3. As expected, it is found that both estimators show positive effects on the disposition to work, of household head (HEAD), a spouse with a job (SP_WORK) and good health status (HEALTH). Among pecuniary factors, earned income of other household members (LAB_OTH), financial assets (FIN) and public pension wealth (PENSION) seem to produce disincentives to work. At the same time, both estimations suggest that the influence of non-pecuniary factors is greater than that of pecuniary factors. Household head, health status and marital status are crucial determinants of working, while income and assets have minimal or statistically insignificant effect.

The coefficients of some variables change sign or statistical significance across the equations. For example, the coefficient on debt (DEBT) changes from negative to positive and furthermore becomes insignificant in a random effects model. On average, the magnitude of the impacts of given variables are greater in the random effects model.

Such differences between the two sets of estimates require a choice to be made between them. To test for the presence of random effects, as noted in Section 3.2.1, we can use the likelihood ratio test for the null hypothesis $H_0 : \rho = \sigma_\mu^2 / (\sigma_\mu^2 + 1) = 0$. As shown in Table 3, the null hypothesis of $H_0 : \rho = \sigma_\mu^2 / (\sigma_\mu^2 + 1) = 0$ is rejected, indicating that the panel-level variance component is important. A Hausman test based on the differences between them suggests the existence of random effects. That is, a χ^2 statistic of 30.27 under the null

hypothesis of no differences between them, that is $\mu_i = \mu$, exceeds the 95% critical value for χ^2-distribution with 16 degrees of freedom, 26.296. It indicates that a random effects probit model is to be preferred to a pooled probit model.

Table 3 Pooled probit estimation without and with random effects

	Model 1: A pooled probit estimation		Model 2: A random effects probit Estimation		
AGE	-0.060224***	(0.008392)	-0.136568***	(0.025562)	[-0.044265]
HEAD	0.565424***	(0.163570)	1.417696***	(0.391628)	[0.305495]
CHILD	0.127014	(0.104322)	0.276787	(0.250897)	[0.089713]
OLD	0.031107	(0.105616)	-0.208408	(0.282895)	[-0.067550]
SP_WORK	0.677762***	(0.119672)	1.118646***	(0.338518)	[0.403178]
HEALTH	0.749885***	(0.094308)	1.064776***	(0.215583)	[0.293959]
SCHOOL	-0.016212	(0.014065)	-0.005650	(0.040765)	[-0.001831]
LAB_OTH	-0.001710***	(0.000438)	-0.002940***	(0.001074)	[-0.000953]
INC_OTH	0.000152	(0.000178)	0.000457	(0.000537)	[0.000148]
REAL	0.000004	(0.000002)	-0.000001	(0.000005)	[-0.0000003]
FIN	-0.000019**	(0.000008)	-0.000027**	(0.000014)	[-0.000009]
DEBT	-0.000006***	(0.000002)	0.000001	(0.000014)	[0.0000004]
PRIVATE	0.000550***	(0.000175)	0.000979	(0.000651)	[0.000317]
PENSION	-0.000022***	(0.000004)	-0.000024*	(0.000013)	[-0.000008]
EDUPC	0.006522	(0.005533)	0.012694	(0.015357)	[0.004114]
UNEMP	-0.130741**	(0.052991)	-0.153516	(0.125748)	[-0.049758]
constant	3.367950***	(0.620445)	6.999817***	(1.760270)	
σ_μ	-		2.550858	(0.293849)	
ρ	-		0.866789	(0.026602)	
Log likelihood	-910.46235		-692.72773		
Wald test for all regressors	$\chi^2(16) = 238.73^{***}$ <0.0000>		$\chi^2(16) = 81.68^{***}$ <0.0000>		
LR test for ρ=0	-		$\chi^2 = 435.47^{***}$ <0.0000>		
A Hausman test for $\mu_i = \mu$			$\chi^2(16) = 30.27^{**}$ <0.0166>		
Pseudo R^2	0.2074		-		
Observations	1684		1684		

- Robust standard errors for a pooled probit estimation and bootstrapped standard errors with 200 replications for a random effects probit model are in parentheses and probabilities are in angle brackets.
- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively
- The marginal effects are in brackets, which are calculated under the assumption of $\mu_i = 0$.

The marginal effects of the variables are given in the square brackets in Table 3. For dummy variables (HEAD, SP_WORK, and HEALTH), a marginal effect implies the effect of a change of state from 0 to 1. Age has a negative impact on the disposition to work among the retired. If it increases by one year, the probability of working decreases by 4.4%. The responsibility as head of the household encourages the individual to work, and its marginal effect is 30.5%. The dependants do not affect the disposition to work, an outcome that differs from the findings by Smeaton and McKay (2003), who found that the caring responsibilities for other adults reduce the labour supply of the elderly in the United Kingdom. However, our finding match those of Sung and Ahn (2006), who use data from the 6th wave of the KLIPS and find that the existence of infants in a household has no effect on the labour force participation in Korea of those aged 50-74.

Having a working spouse (SP_WORK) is the strongest contributor to the labour force participation of the retired, increasing the probability of working by 40.3%. One possible explanation would be a preference for joint leisure found by Blau (1994) and Ozawa and Lum (2005). Another possibility is that individuals and spouses are employed together in a particular sector. These two possibilities are examined in the next sub-section.

Health status (HEALTH) also has a relatively strong effect on the labour supply; with good health increasing the probability of work by 29.4%. This positive impact is consistent with the findings of several studies (Sung and Ahn (2006) for Korea; Smeaton and McKay (2003) for the United Kingdom, Benítez-Silva (2000), Haider and Loughran (2001), Ozawa and Lum (2005) and Schmidt and Sevak (2006), for the United States). The effect of educational attainment (SCHOOL) on labour supply is negative but statistically insignificant, and is in accord with the findings of Blau (1994) and Benitez-Silva (2000) who suggest that the impact of education on labour supply is small or is rarely significant.[15] The studies of Korea's case by Chang (2002) and Sung and Ahn (2006) show that high educational attainment tends to induce the elderly to leave a job. Given that educational attainment is positively correlated with wealth in our data, one tentative hypothesis is that retired individuals with a high educational attainment prepare for retirement through their high earnings so that attainment may have little impact on their labour supply in old age.

Turning to income and assets, we see that they have little impact on the labour force participation of the retired. As expected, the earned income of other household members

[15] It seems to differ from the United States' cases by Haider and Loughran (2001) and Blau and Goodstein (2006).

(LAB_OTH), financial assets (FIN) and the expected public pension wealth (PENSION) seem to produce a disincentive to work. The effect of real estate assets (REAL) on the labour supply of the retired is negative but statistically insignificant, a finding that differs from that of Chang (2002) who finds a positive effect on labour supply of males over the age 45 in Korea, using data from the 4th wave of the KLIPS. That finding seems to be inconsistent with Doling and Horsewood (2003) who show a positive effect of home ownership on retirement of male workers over the age 55 in 19 European countries. One possible reason for this insignificant effect of real estate assets may be related to its *measurement error*; a possibility that is examined in the *following section*. The impact of debt (DEBT) is positive but insignificant. Private pension wealth (PRIVATE) enhances labour supply at the marginal significance level of 13.3%.[16] The impact of educational expenditure (EDUPC) on labour supply of the retired is statistically insignificant, as is the regional unemployment rate (UNEMP) which has a negative effect on the labour supply.

In sum: non-pecuniary factors, such as the presence of a spouse with a job, the position of the household head and good health status, seem to be crucial determinants of labour supply of the retired. The impacts on labour supply of pecuniary factors, such as the earned income of other household members, financial assets and the expected public pension wealth, are negative but weak compared to the effects of the non-pecuniary factors.

5.2 Robust Tests: Self-rated health status; Spouse's work status, respondent's gender and place of residence; and, Measurement of real assets

Before the results reported in Table 3 can be taken as revealing the true value of the potential determinants of the labour participation of the elderly, the following issues need to be addressed. The significance of the role of health in affecting that participation might arise because the self-rated health status embodies measurement error and also is possibly endogenous. The effect of a spouse's work status on the labour supply may depend on the respondent's gender. A related consideration may be that the strong effect of a spouse's work status on the labour supply reflects the situation where those who reside in rural areas may be employed with their spouse in the same, namely, agricultural sector. A final issue is the measurement of real estate assets, which are measured as median value in intervals where their market values are not known. These matters are now examined.

[16] Given that various retirement annuities have been introduced in Korea since 2005, a further study of the effect of such private pension schemes on labour supply need to wait for the collection of more detailed data.

5.2.1 The endogeneity of health status

As remarked in Section 3.2.2, the possible endogeneity of health status can be evaluated by 2SCML estimation. For the first-stage estimation of 2SCML, equation (4) is estimated and then the generalised residuals are obtained by using equation (7), since R_{it} here is a binary variable. One problem is the appropriate instruments to employ: as mentioned in Section 3.2.2, existing studies tend to use objective health measures as instruments. However, it is only since 2003 that the KLIPS has provided relatively objective health indicators, such as functional limitations. As a result, their use as alternative instruments results in the reduction in the sample period and, consequently, in the number of observations. The sample period is reduced from 6 years to 3 years and observations become 1084 from 580 individuals, compared with 1684 observations from 678 individuals in the previous section[17].

To begin with, HEALTH is instrumented by sensory disability (D_SENSORY), physical disability (D_PHYSICAL), cognitive disability (D_COGNITIVE), difficulties in indoor activities (D_INDOOR), difficulties in outdoor activities (D_OUTDOOR) and difficulties in economic activities (D_ECONO). These are added, in that order, as independent variables to equation (8) which is used for the first stage estimation; where now, $V_{it} = \nu_i + \tau_{it}$, ν_i and τ_{it} are individual specific effects and error terms, respectively, and where HEALTH is now the dependent variable. Then at the second stage, the predicted generalised residuals ($\hat{V}_{it}$) from the regression are included as an explanatory variable in equation (8) to test the endogeneity of health status, with $v_t = \mu_i + \varepsilon_{it}$. Since heteroskedastistic is introduced from the first stage estimation, all standard errors are adjusted by using a bootstrapping procedure. The order condition is satisfied because the number of instrumental variables (6) exceeds the number of endogenous explanatory variables (1).

The results are given in Table 2 of Appendix G. As shown there, $\hat{V}_{it}$ (labelled HEALTH_EHAT) is statistically significant at the level of 1%. Hence, it can be concluded that HEALTH is an endogenous explanatory variable and accordingly the endogeneity bias

[17] With 1684 observations as in the previous section, we conducted additional two stage estimations by using alternative instruments for the self-assessed health status, such as the household head's educational attainment and the monthly household expenditure on health and medical services (Table 1 of Appendix G). The estimation showed that self-rated health status is an endogenous explanatory variable and non-pecuniary factors, such as a spouse with a job, health status and the position of the household head, are crucial determinants of the labour supply of the retired. One concern over these alternative instruments is that they may be correlated with other explanatory variables as well as dependent variables, namely work status and health status.

needs to be controlled. To do this, following Mallar (1997) approach, in equation (8), HEALTH is replaced by the predictive index (labelled, HEALTH_PREDICT in Table2 of the Appendix G) from the first stage estimation, where again $v_t = \mu_i + \varepsilon_{it}$.

To evaluate the influence of the endogenous self-rated health status, a random effects probit estimation was conducted with the same sample, namely 1084 observations (Table 3 of Appendix G). It is compared with that model specification in terms of marginal effects, in Table 4.[18]

Table 4 Marginal effects of WORK in two-stage estimation and a random effects estimation

	Model 3: A two-stage probit estimation	Model 4: A random effects probit estimation	$\overline{X}$ (Mean of X)
AGE	-0.057949***	-0.052106***	64.66
HEAD	0.302852***	0.274070***	0.85
CHILD	0.088432	0.067355	0.13
OLD	-0.068846	-0.068298	0.33
SP_WORK	0.719848***	0.670917***	0.23
HEALTH	0.366659***	0.380059***	0.65
SCHOOL	-0.025441	-0.009008	9.06
LAB_OTH	-0.001380**	-0.001237**	72.62
INC_OTH	0.000400	0.000240	73.17
REAL	-0.000002	-0.0000004	19173.30
FIN	-0.000008	-0.000007	2871.91
DEBT	0.000002	0.000001	2659.45
PRIVATE	0.000472*	0.000408	81.63
PENSION	-0.000019***	-0.000018***	10138.90
EDUPC	0.008155	0.005331	3.49
UNEMP	-0.171979**	-0.147077**	2.36
Observations	1084	1084	

- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.

[18] In terms of statistical significance, model (2) in Table 3 and models (3)-(4) in Table 4 differ only slightly. That is, all variables except financial assets, private pension wealth and regional unemployment rate are similar. Particularly, the regional unemployment rate becomes significant at the level of 5% in models (3) and (4). It would lead to a tentative conclusion that the negative impact of regional unemployment rate on the labour supply of the retired has intensified recently. Regarding the magnitude of marginal effects, the comparison between model (2) and model (4) is not straightforward, partly because their measure points differ. On average, models (2) and (4) seem to support the previous findings that SP_WORK, HEALTH and HEAD are crucial determinants of the labour supply of the retired.

The statistical significance of the variables is almost the same in models (3) and (4), except for private pension wealth (PRIVATE). We see that when a self-reported health indicator is instrumented by relatively objective health measures, the marginal effect of health is from 38.0% to 36.7%. Nevertheless, health status remains the second strongest effect on the labour supply of the retired.

So, to reiterate, two implications of these findings are clear. The one is that self-reported health status *may* be biased and needs to be accommodated. The other is that even when it is, health status is still one of the most significant influences on the labour participation of the retired.

5.2.2 Possible asymmetric responses by gender

The possible asymmetric responses by gender are examined with the original dataset, namely, 1684 observations. The results are reported in Table 5. They permit these inferences to be drawn. Males who have a working spouse remain in the labour force. Age and health are also significant determinants of their labour supply. However, for females, all variables except age and health are not significant, and their having a working husband labour does not help determine their labour supply.[19]

[19] Alternative estimations with 1084 observations showed similar results, regardless of considering the endogeneity of health status. That is, the response of men to a spouse's work status is statistically significant. In contrast, it is found that a random effect probit estimation for women is difficult to converge and does not reject the null hypothesis that all regressors are jointly zero.

Table 5 Random effects probit estimations by gender

	Model 5: A random effects probit estimation for men		Model 6: A random effects probit estimation for women	
AGE	-0.114644***	(0.036429)	-0.239709***	(0.090432)
HEAD	1.937951	(1.667126)	0.533572	(1.071015)
CHILD	0.334331	(0.430890)	0.273052	(0.582996)
OLD	-0.421369	(0.283483)	0.115252	(1.333738)
SP_WORK	1.030648***	(0.393652)	0.771842	(1.175803)
HEALTH	1.021750***	(0.233842)	1.124834*	(0.598894)
SCHOOL	-0.032174	(0.047523)	-0.039917	(0.101502)
LAB_OTH	-0.002536*	(0.001347)	-0.005236	(0.004420)
INC_OTH	0.000256	(0.000518)	0.003694	(0.005191)
REAL	0.000001	(0.000006)	-0.000016	(0.000016)
FIN	-0.000028	(0.000018)	-0.000052	(0.000085)
DEBT	0.000005	(0.000019)	-0.000093	(0.000077)
PRIVATE	0.001832	(0.001373)	0.000785	(0.001219)
PENSION	-0.000025*	(0.000013)	-0.000054	(0.000065)
EDUPC	0.020801	(0.022379)	0.015398	(0.059345)
UNEMP	-0.116799	(0.154693)	-0.378133	(0.382291)
constant	5.378409***	(2.079124)	14.669170**	(6.221095)
σ_μ	2.407937	(0.348758)	3.431069	(0.987999)
ρ	0.852901	(0.036343)	0.921705	(0.041561)
Log likelihood	-495.85815		-182.48168	
Wald test for all regressors	$\chi^2(16) = 43.64^{***}$ <0.0002>		$\chi^2(16) = 11.03$ <0.8076>	
LR test for ρ=0	$\chi^2 = 295.48^{***}$ <0.0000>		$\chi^2 = 435.47^{***}$ <0.0000>	
Observations {individuals}	1192 {449}		492 {229}	
	1684 {678}			

- Bootstrapped standard errors with 200 replications are in parentheses and probabilities are in angle brackets.
- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.

5.2.3 Labour supply of the retired by region

The findings reported in Table 6 imply that the determinants of the labour supply of the retired can have different patterns by residential area[20]. We note again that the significance of variables is based on bootstrapped standard errors with 200 replications.

Table 6 Random effects probit estimations by residential area

	Model 7: A random effect probit estimation for urban areas		Model 8: A random effect probit estimation for rural areas	
AGE	-0.127159***	[-0.041372]	-0.159187***	[-0.053966]
HEAD	0.907535	[0.229518]	2.061605***	[0.395356]
CHILD	0.335172	[0.109051]	0.226246	[0.076700]
OLD	-0.316616	[-0.103014]	-0.144542	[-0.049002]
SP_WORK	0.641907	[0.224002]	1.626255***	[0.580477]
HEALTH	0.772093**	[0.227889]	1.406951***	[0.386968]
SCHOOL	0.030362	[0.009878]	-0.024052	[-0.008154]
LAB_OTH	-0.002980**	[-0.000970]	-0.003209*	[-0.001088]
INC_OTH	0.000515	[0.000168]	0.000053	[0.000018]
REAL	-0.000005	[-0.000002]	0.000003	[0.000001]
FIN	-0.000017	[-0.000006]	-0.000065	[-0.000022]
DEBT	0.000020	[0.000007]	0.000000	[0.000000]
PRIVATE	0.000723	[0.000235]	0.002580**	[0.000875]
PENSION	-0.000025	[-0.000008]	-0.000026	[-0.000009]
EDUPC	0.003894	[0.001267]	0.035999	[0.012204]
UNEMP	-0.156430	[-0.050896]	-0.141452	[-0.047954]
constant	6.779075**		7.700274**	
σ_μ	2.284648	(0.4678519)	2.964345	(0.5404514)
ρ	0.8392184	(0.0552625)	0.8978272	(0.0334492)
Log likelihood	-322.4208		-361.80277	
Wald test for all regressors	$\chi^2(16) = 22.24$ <0.1355>		$\chi^2(16) = 39.74^{***}$ <0.0000>	
LR test for ρ=0	$\chi^2 = 156.50$ <0.0000>		$\chi^2 = 261.42^{***}$ <0.0000>	
Observations {individuals}	729 {320}		955 {368}	

- The marginal effects are in brackets, which are calculated under the assumption of $\mu_i = 0$, standard errors are in parentheses and probabilities are in angle brackets.
- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.

[20] The KLIPS classifies the residential area into Seoul, 6 metropolitan cities and 9 provinces. Hence, for convenience, the first two categories are considered as urban areas and the third is regarded as a rural area.

The labour supply of residents of both rural and urban areas responds negatively to age (AGE). The position of the household head (HEAD) is significant at the level of 12.2% in urban areas, compared to the 1% level in rural areas. The expected public pension wealth (PENSION) is significant at the 13.2% level in urban areas, while it is insignificant at the conventional level in rural areas. The distinctive difference between them is found in the responses to a spouse with a job (SP_WORK). The retired who are living in rural areas are likely to increase labour supply. In contrast, the spouse's work status does not affect the labour supply of the retired who reside in urban areas. Lee (2003) finds that the male labour supply is higher in rural areas than it is in urban areas and that of the age group 70 and over has an upward trend; Choi (2003) finds that the labour supply of the old of both sexes have upwards trends in the farm sector. The latter finding, as we have noted earlier, is likely to be because spouses tend to work together in the agricultural sector.

5.2.4 A possible measurement error in real estate assets

To accommodate the possible measurement error of real estate assets, as mentioned earlier, an alternative estimation was conducted by using a dummy variable (HOUSE), assigned the value of 1 if a household has home ownership and 0 otherwise. The estimates are given in Table 7, where again the significance of variables is derived from bootstrapped standard errors with 200 replications.

It is model (2) in Table 3 that is replicated in Table 7 using the alternative definition of real assets. The estimates reveal that, on average, the statistical significance of variables and their marginal effects are similar in both model specifications; the exception being for real estate assets (REAL), and their new measurement (HOUSE). The impact of the real estate variable turns from negative to positive in model (9): but remains statistically insignificant. Hence, the actual values or median values in intervals, as in model (2), might not induce measurement error into real estate assets[21].

[21] Alternative estimations with 1084 observations showed similar results, regardless of whether or not the endogeneity of health status was taken into account.

Table7 Marginal effects of alternative measures of real estate assets

	Model 2: A random effect probit estimation		Model 9: A random effect probit estimation		$\overline{X}$
AGE	-0.136568***	[-0.044265]	-0.136466***	[-0.044324]	64.13
HEAD	1.417696***	[0.305495]	1.414307***	[0.306026]	0.84
CHILD	0.276787	[0.089713]	0.280223	[0.091016]	0.16
OLD	-0.208408	[-0.067550]	-0.210058	[-0.068226]	0.32
SP_WORK	1.118646***	[0.403178]	1.112584***	[0.401376]	0.22
HEALTH	1.064776***	[0.293959]	1.060816***	[0.293788]	0.68
SCHOOL	-0.005650	[-0.001831]	-0.006594	[-0.002142]	9.17
LAB_OTH	-0.002940***	[-0.000953]	-0.002972***	[-0.000965]	73
INC_OTH	0.000457	[0.000148]	0.000455	[0.000148]	68
REAL	-0.000001	[-0.0000003]			17,979
HOUSE			0.059951	[0.019212]	0.84
FIN	-0.000027**	[-0.000009]	-0.000027*	[-0.000009]	2,776
DEBT	0.000001	[0.0000004]	0.000001	[0.000000]	2,598
PRIVATE	0.000979	[0.000317]	0.000974	[0.000316]	67
PENSION	-0.000024*	[-0.000008]	-0.000025**	[-0.000008]	10,820
EDUPC	0.012694	[0.004114]	0.012542	[0.004074]	2.52
UNEMP	-0.153516	[-0.049758]	-0.154799	[-0.050279]	3.56
constant	6.999817***		6.957953***		
σ_μ	2.550858	(0.293849)	2.540413	(0.289275)	
ρ	0.866789	(0.026602)	0.865838	(0.026455)	
Log likelihood	-692.72773		-692.72057		
Wald test for all regressors	$\chi^2(16) = 81.68^{***}$ <0.0000>		$\chi^2(16) = 76.93^{***}$ <0.0000>		
LR test for ρ=0	$\chi^2 = 435.47^{***}$ <0.0000>		$\chi^2 = 437.7^{***}$ <0.0000>		
Observations	1684		1684		

- The marginal effects are in brackets, which are calculated under the assumption of $\mu_i = 0$, $\overline{X}$ is the mean of X, standard errors are in parentheses and probabilities are in angle brackets.
- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.

6 Concluding observations

Korea is a remarkable country showing rapid economic growth which has propelled it to advance economy status and membership of the OECD within a few decades. Yet, it exhibits socio-economic and cultural characteristics of a developing country in terms of familial

support and lack of a well-developed welfare state. At the same time as its economic miracle was occurring, Korea was blessed with a demographic dividend in so far as the human capital intensive labour force participation ratio increased dramatically. However, in the future this dividend may morph into a demographic disaster as population falls and the old outnumber the young. Thus, Korea exhibits the microcosm of a large number of traits that are present in many other parts of the world, when it comes to an in-depth study to indentify the determinants of the labour supply of the elderly. In this paper we attempt to conduct a detailed panel data estimate of the variables which influence the labour supply decision (work or not work in a discrete choice framework) for a panel data set for Korea between 2000-2005. The results reported here are derived from a random effects probit model; and we have controlled for possible measurement error or possible endogeneity bias, by means of a two stage panel probit model.

Our main motivation was to enquire as to whether pecuniary and related economic factors were important in making the retired and the elderly go back to work or not. Alternatively, whether non-pecuniary factors, (such as health, marital status or rural/urban habitation) were dominant in determining the work status of the old. The dominant result we obtain from a rather complex battery of models and tests, is that non-pecuniary factors dominate and the elderly are less or insignificantly motivated by pecuniary factors. This is contrary to expectations since Korea does not have a fully fledged welfare state and pension support system, similar to many other developing countries, yet the elderly are less motivated by issues such as income, assets and expected wealth from pension benefits.

The most important non-pecuniary factor, in our assessment, is the health status of the elderly. Thus, we investigate in some detail the impact of health on the willingness (or ability) to work. We also analyse whether the retired tend to use health status as an excuse or justification for not working. Even when its endogeneity is considered, health status holds its significant role in the labour supply of the retired. For example, if an individual is in good health, the probability that he/she will be in work as a retired person increases by a substantial amount A related important non-pecuniary factor is the working status of the spouse and the area where the person resides (rural or urban). Some of these factors are important in developing countries and here the Korean case may be able to mimic that of relatively poorer countries. Having a spouse who has a job is shown to be one of the most significant contributors to the labour supply of the retired. Particularly, men have a statistically significant response to their spouses' work status. In addition, the retired who

reside in rural areas seem to respond positively to a spouse's work status, while those living in urban areas are not so affected.

Retired elderly people work because they want to, not because they need to. Public policy therefore must be pro-active and try to increase the ability and motivation of the old to work longer. Then there will be less pressure on state funding and government pensions to look after the aged financially and provide for their economic needs. In a diversified labour market, the elderly are happy to work productively after retirement provided they are physically able to.

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Appendix A Male labour force participation rates by age cohort, various countries

(unit: %)

	55-59				60-64				65-69				70+			
	1980	1990	2000	2005	1980	1990	2000	2005	1980	1990	2000	2005	1980	1990	2000	2005
USA	81.7	79.9	77.0	77.6	60.8	55.5	55.0	58.0	28.5	26.0	30.3	33.6	13.1	10.7	12	13.5
Japan	91.2	92.1	94.2	93.6	77.8	72.9	72.6	76.4[7]	60.1	54.1	51.1	49.6[7]	28.4	26.3	24.3	20.4[7]
Germany	81.9	75.8	76.1	82.2	44.3	33.6	30.2	40.7			7.2[3]	8.5				
Australia	82.6	75.0	72.4	75.1	51.5	50.6	46.6	54.7	16.9	14.1	18.6	23.5	7.2	6.0	6.1	6.1
France	81.0	67.7	65.8	62.7	47.9	22.8	15.5	15.5		6.5[2]	3.7	3.4				
Greece	78.7[1]	72.3	72.1	73.2	59.8[1]	46.0	45.2	44.9			16.1[4]	15.6			3.7[4]	3.1
Ireland		74.9[2]	73.9	73.9		55.6[2]	53.7	60.0		27.2[2]	23.7[5]	24.0				
Sweden	87.7	87.4	84.5	85.9	69.2	63.6	56.7	65.5	17.3	16.2	17.8	19.4				
Portugal	81.2	75.2	73.2	73.1	66.0	56.8	55.4	49.5			33.5	35.2			18.4[5]	19.5
Korea	76.4	81.7	71.9	74.3	65.4	64.2	58.1	59.0	51.0	49.4	46.7	50.0	25.3	26.3	29.3	33.7
China	83.0	83.5	83.3	83.2	63.2	63.2	66.5	67.9	30.6[6]	32.7[6]	28.0[6]	26.0[6]				

- Source: Lee, C. (forthcoming) for Korea, ILO for China, NSC for Japan, BLS for USA and the OECD employment database for other countries.
- 1, 2, 3, 4 and 5 indicate 1983, 1991, 1999, 2002 and 1998 respectively.
- 6 indicates people aged 65 and over.
- 7 and 8 indicate 2008 and 1986, respectively.

Appendix B Pensioners (persons) by pension

Pension	National Pension Scheme			Special Occupational Pension Scheme			Tot.
Type / Year	Old age	Disability	Survivors	Teachers	Government employees	Military	
2000	76	4	10	3	39	6	138
2001	127	7	17	4	47	12	214
2002	150	14	15	4	51	14	248
2003	173	14	24	4	52	16	283
2004	235	13	27	3	61	13	352
2005	312	21	32	7	62	15	449
Tot.	1073	73	125	25	312	76	1684

Appendix C Pensioners (persons) by pension scheme and by age

Pension	National Pension Scheme								Special Occupational Pension Scheme							
Age / Year	~ 49	50 ~ 54	55 ~ 59	60 ~ 64	65 ~ 69	70 ~ 74	75 ~	Tot.	~ 49	50 ~ 54	55 ~ 59	60 ~ 64	65 ~ 69	70 ~ 74	75 ~	Tot.
2000	2	5	5	40	26	5	7	90	3	4	7	21	7	3	3	48
2001	10	6	12	65	43	9	6	151	3	6	8	24	12	7	3	63
2002	7	6	8	77	42	30	9	179	6	5	9	17	22	8	3	69
2003	8	7	12	76	56	33	19	211	5	3	10	17	19	10	8	72
2004	11	7	9	124	70	31	23	275	2	3	12	17	26	9	8	77
2005	11	8	22	159	99	42	24	365	3	1	14	17	26	14	9	84
Tot.	49	39	68	541	336	150	88	1271	22	22	60	113	112	51	33	413

Appendix D Pensioners (persons) by residential area and by gender

	Rural			Urban		
	Female	Male	Tot.	Female	Male	Tot.
2000	22	53	75	17	46	63
2001	41	86	127	22	65	87
2002	41	103	144	24	80	104
2003	50	110	160	34	89	123
2004	62	137	199	39	114	153
2005	84	166	250	56	143	199
Tot.	300	655	955	192	537	729

Appendix E Calculation of private pension wealth and public pension wealth

A. Private pension wealth (PRIVATE)

For Korea, a personal pension scheme was first available in 1994 and retirement annuities were introduced at the end of 2005. Therefore, considering the sample period of 2000-2005, private pension wealth needs to be restricted to a personal pension scheme. The difficulty is that the KLIPS provides only the monthly amount which was put into a personal pension scheme but gives no detailed information on the personal pension scheme, such as pension type, interest rate, and insured period. In these circumstances, one way to construct a variable about personal pension is to form a dummy variable for each period. For example, a value of 1 can be given if a household contributes to a personal pension scheme during the year. The problem of this method is that it does not consider how often and how much the household put into the pension scheme in the past. In other words, it does not treat personal pension as an accumulated asset but as a simple cash flow. In this context, the calculation of the present value of personal pension needs to be conducted with some assumptions about the insured period and interest rate. The present value of personal pension at a specific year is computed by adding the value of past contributions accumulated up to the year to the present value of the future contribution discounted with a discount rate. In other words, the present value of personal pension benefits can be calculated in the following equation (E1).

$$\begin{aligned} PRIVATE_{2000+t-1} = & \sum_{q=0}^{t-1}\left(Pri_{pen_{2000+q-1}} \times \prod_{s=t-1}^{t-q}\left(1+r_{2000+s-1}\right)\right) \\ & + \sum_{i=t}^{T}\left(Pri_{pen_{2000+i-1}} \times \prod_{j=0}^{i-t}\left(1/\left(1+d_{2000+t+j-1}\right)\right)\right) \quad t=1,\cdots,T \end{aligned} \tag{E1}$$

where Pri_{pen_t} is a personal pension contribution in the year t, r_t and d_t are interest rate and a discount rate in t year and $Pri_{pen_{1999}}$ and r_{1999} are assumed to be zero respectively.

Equation (E1) requires some assumptions about the insured period and interest rate. To make the assumptions more reasonable, it would be better to consider the main features of a general personal pension scheme. They can be summarized as; i) a 10-year minimum insured period ii) no mandatory contribution for every period iii) a minimum contribution over all insured periods and iv) a minimum entitlement age of 55 years. Among them, ii) and iii) make it difficult to assume the insured period and contribution amounts in the past and in the future. For example, to receive personal pension benefits, an individual does not need to contribute for every period and can contribute irregularly if the minimum contribution

criterion is satisfied over all of the insured period. It indicates that it is difficult to predict future contributions based on past behaviour. In this context, regarding contribution amounts, only the observed amounts over the sample period are used to construct PRIVATE. As for the insured period, it is assumed that whoever put money into the personal pension scheme during the sample period starts to contribute from 2000, which is the first sample period. In addition, contribution is supposed to end in 2009, which satisfies a 10-year minimum insured period. For convenience, the interest rate and discount rate are assumed to be the yield on 3-year corporate bonds from 2000 to 2007. For them after 2007, this study follows the forecast by Han et al. (2007).

B. Public pension wealth (PENSION)

On the basis of Feldstein (1974), public pension wealth is derived as the actuarially discounted present value of future benefits. It is obtained by discounting them with both an interest rate and a probability of survival until a certain age[22]. Meanwhile, both the NPS and three special occupational pension schemes have the indexation system to maintain the real value of pension amounts. In other words, pension benefits are adjusted annually to maintain the real value of pension amounts by reflecting changes in the CPI over the previous year[23]. It indicates that pension benefits grow at the rate of c_t, which is the change of the CPI over the previous year. Therefore, the present value of pension benefits can be derived from the following equation (E2).

$$PENSION_{a\,t} = \sum_{n \geq a} \left\{ Pamount_{a\,t} \times \prod_{j=0}^{n-a} (1 + c_{t+j}) \times S_{n\,a} \times \prod_{q=0}^{n-a} [1/(1 + d_{t+q})] \right\} \qquad \text{(E2)}$$

where $Pamount_{a\,t}$ is a pension benefit amount at age a in the year t, c_t is the change of CPI over the previous year, $S_{n\,a}$ is a probability of survival until age n at age a and d_t is an interest rate.

As was the case for equation (E1), equation (E2) requires some assumptions to b formed about about discount rates, inflation rates and probabilities of survival. Inflation rates

[22] Bernheim (1984) suggests that under the missing annuity market, the value of the annuity which pays $1 every year can be equivalent to that of the bequeathable wealth which pays $1 every year. In this regard, he insists that a simple discounted value with an interest rate is often a good approximation to the present value of the future benefits in an incomplete annuity market. However, Jousten (2001) contends that the assumption on an annuity market is not required in the annuity valuation. He shows that regardless of the existence of annuity markets, an actuarial discounted value can be a valid approximation to the present value of the future benefits in the presence of a sufficiently strong bequest motive.

[23] In special occupation pension schemes, an adjustment rate depends on the growth rate of public servants' salary or the change of CPI. However, the former has been smaller than the latter since 2003. In this context, beyond the sample period 2000-2005, the change of CPI is assumed to be an adjustment rate.

(c_t) are based on the CPI (2005=100) provided by the KNSO. The 2008-2050 figures come from the forecast by Han et al. (2007). Survival probabilities are constructed from the standard life tables by age and gender published by the KNSO. However, the life tables are available for the years 1999 and 2001-2006. Therefore, the 2000 figures are calculated as the average value of 1999 and 2001. The probability that an individual of age *a* will survive until age *m* in the year *t* is calculated with the following formula.

$$S_{m\,a} = \frac{P_{m\,t}}{P_{a\,t}}$$

where $S_{m\,a}$ is a probability of survival until age *m* at age *a*, $P_{m\,t}$ is the number of survivors at the age *m* in the year *t* and $P_{a\,t}$ is the number of survivors at the age *a* in the year *t*. The same discount rate (d_t) which is used in the derivation of PRIVATE is used in equation (E2).

Appendix F Descriptive statistics of variables (Unit: years, 10 thousand Kwon, %)

Variable	Mean						Mean	S.D.	Min	Max
	2000	2001	2002	2003	2004	2005				
WORK	0.40	0.43	0.42	0.42	0.45	0.42	0.43	0.49	0.00	1.00
AGE	63.02	62.63	63.70	64.81	64.56	64.65	64.13	7.54	30.00	93.00
HEAD	0.81	0.82	0.84	0.86	0.85	0.84	0.84	0.37	0.00	1.00
CHILD	0.18	0.31	0.17	0.13	0.13	0.13	0.16	0.50	0.00	5.00
OLD	0.30	0.29	0.32	0.35	0.33	0.33	0.32	0.50	0.00	2.00
SP_WORK	0.19	0.23	0.23	0.19	0.24	0.23	0.22	0.42	0.00	1.00
HEALTH	0.78	0.64	0.83	0.60	0.68	0.65	0.68	0.46	0.00	1.00
SCHOOL	9.71	9.45	9.15	8.99	9.19	8.99	9.17	4.89	0.00	21.00
LAB_OTH	65	80	73	69	75	73	73	140	0	2,548
INC_OTH	57	60	59	89	74	63	68	248	0	6,080
REAL	17,032	15,324	15,575	17,373	18,793	20,606	17,979	25,139	0	250,000
FIN	2,625	2,302	2,853	2,244	2,732	3,377	2,776	7,077	0	120,000
DEBT	1,853	3,003	2,394	3,451	1,962	2,707	2,598	12,734	0	250,000
PRIVATE	18	36	60	72	82	87	67	274	0	4,914
PENSION	13,954	11,385	11,567	11,044	10,642	9,174	10,820	14,646	20	70,946
EDUPC	2.61	2.64	3.03	2.27	2.45	2.35	2.52	9.09	0.00	125.00
UNEMP	4.43	3.85	3.11	3.37	3.52	3.55	3.56	1.03	1.80	7.10
Observations	138	214	248	283	352	449	1684			

Appendix G: Table 1 A random effect probit estimation and two-stage probit estimations (1684 observations)

(Dependent variable)	A random effects probit estimation(WORK)		Two-stage estimations					
			First-stage probit(HEALTH)		Second-stage probit(WORK)		Second-stage probit(WORK)	
AGE	-0.136582***	(0.027490)	-0.013422*	(0.008234)	-0.128117***	(0.026976)	-0.134774***	(0.030095)
HEAD	1.417791***	(0.413960)	-0.134495	(0.178822)	1.668376***	(0.515946)	1.644716***	(0.524467)
CHILD	0.276814	(0.270031)	-0.097748	(0.107538)	0.306354	(0.254177)	0.281977	(0.273915)
OLD	-0.208451	(0.242239)	-0.088670	(0.117636)	-0.099949	(0.263364)	-0.167063	(0.278929)
SP_WORK	1.118671***	(0.347176)	0.095297	(0.138633)	1.050823***	(0.348023)	1.077221***	(0.385434)
HEALTH	1.064798***	(0.207431)			3.730107***	(1.247864)		
SCHOOL	-0.005651	(0.038311)	0.030044	(0.029175)	-0.085116	(0.053705)	-0.079426	(0.069877)
LAB_OTH	-0.002940***	(0.001119)	0.000076	(0.000429)	-0.003093***	(0.001028)	-0.003056***	(0.001211)
INC_OTH	0.000457	(0.000509)	-0.000211	(0.000181)	0.000616	(0.000495)	0.000637	(0.000544)
REAL	-0.000001	(0.000005)	0.000006**	(0.000003)	-0.000005	(0.000005)	-0.000007	(0.000006)
FIN	-0.000027*	(0.000016)	0.000004	(0.000007)	-0.000030*	(0.000016)	-0.000031*	(0.000016)
DEBT	0.000001	(0.000011)	-0.000005	(0.000005)	0.000005	(0.000016)	0.000005	(0.000012)
PRIVATE	0.000979*	(0.000602)	-0.000114	(0.000195)	0.001087*	(0.000571)	0.001093*	(0.000658)
PENSION	-0.000024**	(0.000012)	0.000005	(0.000005)	-0.000026**	(0.000013)	-0.000027**	(0.000013)
EDUPC	0.012695	(0.013897)	-0.004029	(0.006865)	0.017684	(0.017185)	0.018716	(0.015134)
UNEMP	-0.153521	(0.124884)	-0.048637	(0.056967)	-0.129731	(0.137729)	-0.125961	(0.136782)
HSCHOOL			0.073825***	(0.028710)				
MEDICAL			-0.010557***	(0.002626)				
HEALTH_EHAT					-1.564461**	(0.709357)		
HEALTH_PREDICT							1.051966**	(0.513260)
Constant	7.000542***	(1.852551)	0.853349	(0.601857)	4.995598***	(1.991479)	7.344746***	(2.040423)
σ_μ	2.49582	(0.255)	1.007727	(0.095)	2.570176	(0.260)	2.782043	(0.352)
ρ	0.86167	(0.024)	0.5038488	(0.047)	0.868521	(0.030)	0.8855804	(0.026)
Log likelihood	-678.14464		-899.06388		-689.47376		-705.56091	
Wald test for X	$\chi^2(17) = 120.39^{***}$		$\chi^2(17) = 92.57^{***}$		$\chi^2(17) = 61.89^{***}$		$\chi^2(16) = 65.60^{***}$	
LR test for ρ=0	$\chi^2 = 429.67^{***}$		$\chi^2 = 131.80^{***}$		$\chi^2 = 434.34^{***}$		$\chi^2 = 486.27^{***}$	

- Standard errors are in parentheses and standard errors in the second stage estimation are bootstrapped.
- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.

Appendix G: Table 2: Two-stage probit estimation with objective health measures (1084 observations)

(Dependent variable)	Model 3					
	First-stage probit(HEALTH)		Second-stage probit(WORK)		Second-stage probit(WORK)	
AGE	0.013190	(0.010675)	-0.200225***	(0.052388)	-0.207080***	(0.030095)
HEAD	-0.312018	(0.225070)	1.988357**	(0.812547)	2.182230***	(0.524467)
CHILD	-0.026963	(0.175061)	0.311497	(0.587302)	0.316012	(0.273915)
OLD	0.082987	(0.159416)	-0.211983	(0.406540)	-0.246023	(0.278929)
SP_WORK	0.023427	(0.191266)	2.129070***	(0.685994)	2.218387***	(0.385434)
HEALTH	0.092046	(0.021596)	4.625015***	(1.061314)		
SCHOOL	0.000119***	(0.000671)	-0.053665	(0.064504)	-0.090914	(0.069877)
LAB_OTH	0.000036	(0.000266)	-0.004807**	(0.002127)	-0.004930**	(0.001211)
INC_OTH	0.000003	(0.000003)	0.001218*	(0.000684)	0.001428	(0.000544)
REAL	-0.000003	(0.000009)	-0.000003	(0.000008)	-0.000007	(0.000006)
FIN	0.000003	(0.000006)	-0.000030	(0.000032)	-0.000027	(0.000016)
DEBT	-0.000092	(0.000248)	0.000006	(0.000026)	0.000006	(0.000012)
PRIVATE	-0.000003	(0.000007)	0.001663	(0.001122)	0.001686*	(0.000658)
PENSION	-0.000226	(0.009089)	-0.000071***	(0.000024)	-0.000070***	(0.000013)
EDUPC	-0.006766	(0.083506)	0.025490	(0.025884)	0.029142	(0.015134)
UNEMP	-0.191916	(0.283153)	-0.619170**	(0.273360)	-0.614568**	(0.136782)
D_SENCE	-1.250292	(0.219308)				
D_PHYSIC	-0.382989***	(0.245471)				
D_INDOOR	-0.087337	(0.478227)				
D_OUTDOOR	-0.716811*	(0.387476)				
D_ECONOMIC	-1.046849	(0.225938)				
HEALTH_EHAT			-1.855266***	(0.528047)		
HEALTH_PREDICT					1.310258***	(0.513260)
constant	-0.220325	(0.776111)	10.335880***	(3.391485)	13.311400***	(2.040423)
σ_μ	1.048115	(0.148)	3.629355	(0.659)	3.728645	(0.662)
ρ	0.5234796	(0.070)	0.9294394	(0.024)	0.9328985	(0.022)
Log likelihood	-471.12721		-445.5556		-446.38858	
Wald test for X	$\chi^2(21) = 129.81^{***}$		$\chi^2(17) = 32.32^{**}$		$\chi^2(16) = 29.67^{**}$	
LR test for ρ=0	$\chi^2 = 45.53^{***}$		$\chi^2 = 244.76^{***}$		$\chi^2 = 253.98^{***}$	

- Standard errors are in parentheses and standard errors in the second stage estimation are bootstrapped with 200 replications.
- and ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.

Appendix G: Table 3 A random effects probit estimation (1084 observations)

	Model 4	
AGE	-0.180124***	(0.046798)
HEAD	1.603404**	(0.673269)
CHILD	0.232839	(0.478017)
OLD	-0.236099	(0.356263)
SP_WORK	2.012521***	(0.509914)
HEALTH	1.638872***	(0.349334)
SCHOOL	0.031139	(0.061837)
LAB_OTH	-0.004278**	(0.001819)
INC_OTH	0.000830	(0.000604)
REAL	0.000001	(0.000007)
FIN	-0.000025	(0.000030)
DEBT	0.000003	(0.000021)
PRIVATE	0.001411	(0.000935)
PENSION	-0.000064***	(0.000021)
EDUPC	0.018430	(0.023852)
UNEMP	-0.508429**	(0.250356)
constant	10.294880***	(3.242764)
σ_μ	3.291666	(0.5192259)
ρ	0.9155053	(0.024404)
Log likelihood	-462.39033	
Wald test for all regressors	$\chi^2(16) = 43.17^{***}$ <0.0000>	
LR test for ρ=0	$\chi^2 = 239.58^{***}$ <0.0000>	

- Standard errors are in parentheses and probabilities are in angle brackets.
- ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% level respectively.