Health Status and Labour Force Participation: Evidence from the HILDA Data *

Lixin Cai and Guyonne Kalb
Melbourne Institute of Applied Economic and Social Research
The University of Melbourne

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Melbourne Institute of Applied Economic and Social Research
The University of Melbourne
Victoria 3010 Australia
***Telephone* (03) 8344 5330**
***Fax* (03) 8344 5630**
***Email* melb-inst@unimelb.edu.au**
***WWW Address* http://www.melbourneinstitute.com**

Abstract

Although the overseas literature on the effect of health on labour force participation is extensive, especially in the US, the literature in an Australian context is scarce. This paper contributes to the understanding of this issue using the recently released Household, Income and Labour Dynamics in Australia (HILDA) Survey data. The potential endogeneity of the health variables, especially self-assessed health, in the labour force participation equation is addressed by estimating the health equation and the labour force participation equation simultaneously. We also take into account the correlation between the error terms in the two equations to obtain an efficient result. The null-hypothesis of exogeneity of health to labour force participation is tested based on a test of the joint significance of the labour force participation variable in the health equation and the correlation coefficient of the two error terms.

The estimation is conducted separately for males aged 15 to 49, males aged 50 to 64, females aged 15 to 49 and females aged 50 to 60. The results indicate that better health increases the probability of labour force participation for all four groups. As for the feedback effect, it is found that labour force participation has a significant positive impact on older females' health, and a significant negative effect on younger males' health. For younger females and older males, the impact of labour force participation on health is not significant. Based on the joint test, the exogeneity hypothesis is rejected for all four groups.

1. **Introduction**

In this paper we examine the relationship between labour force participation and health of men and women of all ages. The focus in the literature has been mostly on older working age (white) men and was motivated by an increase in the incidence of early retirement of older men. The effects of health on the retirement or labour force participation decision of older working age men have been extensively examined. After an extensive review of the literature, Currie and Madrian (1999, p 3353) conclude that “a glaring limitation of the existing literature is the intense focus on elderly white men, to the virtual exclusion of most other groups. Studies to remedy this situation would be most useful”.

The reason to look at the relationship between health and labour force participation more broadly is that if health limitations reduce labour productivity and lead to reduced participation by those with poor health (not just older men), health problems impose a cost on the economy in terms of production loss. An indication that this may be a relevant problem is the increase in the number of people who receive a social security payment associated with being disabled. A better understanding of the relationship between health and labour market outcomes is necessary to estimate the costs of health limitations to the economy (Chirikos, 1986, 1993; Haveman, Wolfe, Buron and Hill, 1992; and Salkever, 1984).

Notwithstanding the broader focus of this paper, we agree that understanding the relationship between health and labour market behaviour of older working age men has important policy implications in the context of population ageing. With an ageing population, it becomes important to keep older working age people in the labour force for at least two reasons: (a) to contain the rapidly increasing demand for public expenditure on income support for mature-age people; and (b) to maintain sufficient supply of labour to support national production. Many developed nations have been attempting to develop policies to encourage older workers to remain active in the labour market. Clearly the success of such policies would depend on better understanding the impact of health on labour market activity, especially labour force participation, of older working age people.

Although the effect of health on labour market activities has been under extensive examination overseas and many research papers have been generated, Australian researchers have not looked at this issue to the same extent.[1] There is just one paper looking at the impact of disability on labour supply (including employment probability and hours worked) and income support dependency (Wilkins, 2003). There is another paper looking at the impact of disability on earnings (Brazenor, 2002). Both studies use the 1998 Survey of Disability, Ageing and Carers (SDAC) collected by the Australian Bureau of Statistics (ABS).

The disability status in SDAC is derived from a combination of long-term health conditions and specific activity restrictions. As such, it has the advantage of being more objective than the self-assessed health status used in most studies in the literature and it is less likely to be subject to the rationalisation endogeneity problem associated with self-assessed measures of health status. However, this definition will exclude some individuals in poor health because poor health may not necessarily manifest itself in the form of disabilities. For example, a person without any activity restriction may not be as healthy as a person with certain restrictions. In this sense, the disability definition used in SDAC may provide a narrower measure of health status than a more subjective measure.

However, even objective measures of health can be endogenous to individuals' labour market behaviours. Thus, a simultaneous equation modelling approach with two correlated equations for labour force participation and health may be more appropriate for estimating the effect of health on labour force participation than a single equation for labour force participation with health as an exogenous explanatory variable. Few researchers have used a simultaneous modelling approach. We follow Stern (1989), but we use the full information maximum likelihood (FIML) estimation method to estimate the simultaneous equations, which is more efficient than the two-stage estimation method employed by Stern when more than two levels of health are distinguished.

[1] Chirikos (1993) and Currie and Madrian (1999) provide comprehensive reviews of the literature in the US. The studies on this issue were generally motivated by the increasing number of withdrawals by older working age (white) men from the labour market, known as early retirement, and the negative relationship between health and age.

This paper uses data from the recently released Household, Income and Labour Dynamics in Australia (HILDA) Survey to examine the effect of health on labour force participation of working age people in Australia. The advantage of HILDA data is that, in addition to standard health measures, the data also contain information on the employment history of both employed and unemployed persons, which provides us with an opportunity to examine the impact of previous labour market experience on current health status and labour force participation.

The paper is arranged as follows: Section 2 briefly discusses some modelling issues regarding the relationship between health status and labour force participation and outlines the modelling strategy. Section 3 describes the data and model specifications. Section 4 presents the estimation results. Section 5 concludes the paper.

2. The relationship between health and labour force participation

2.1. Theory

Although the discussion here focuses on labour force participation, most of the arguments also apply to labour supply in general. A formal approach relating health and labour market behaviour treats health as human capital. Becker (1964) drew an analogy between "investment" in health and in other forms of human capital such as education. This approach was further developed by Grossman (1972). See Currie and Madrian (1999) for a detailed discussion. In this approach, both employees and employers value health like they value education because health and the capacity or ability to perform a job adequately are closely related. Obviously, poor health is likely to have an adverse effect on work performance and leads to lower productivity. As a result, people with poor health have a lower probability of being employed under prevailing wages. On the other hand, low productivity associated with poor health decreases individuals' earning potential, the opportunity costs of leisure and therefore their willingness to participate in the labour force. Thus, according to human capital theory, health and labour force participation (or labour supply in general) are positively correlated. That is better health is likely to lead to a higher probability of labour force participation.

However, productivity may not be the only link between health and labour supply. Onset of some health problems may change the individual's relative utility derived from income and time out of the labour market, even if these problems do not have any impact on the individual's productivity. For example, poor health may cause individuals to value time out of the labour market more since the time needed to care for one's health increases with ill health. Also, by affecting life expectancy, poor health may make withdrawal from the labour market more attractive by influencing the time horizon over which economic decisions are made (Chirikos, 1993). Like human capital theory, these arguments predict that poor health leads to lower labour supply and a lower probability of labour force participation. Hence, the impact of health on labour supply may operate through influencing individual preferences or through influencing the ability to fulfil job requirements. The literature has not been able to discriminate between these two effects (Chirikos, 1993).

The above arguments suggest that poor health reduces the probability of labour force participation. However, it could also be argued that low earnings associated with poor health may have an income effect, which could then increase labour supply. In addition, poor health implies individuals may need more health services. To meet the increased demand for health services, individuals may need to work more. Therefore, theoretically, the exact direction of the effect of health on labour supply is not clear (Dwyer and Mitchell, 1999), although most empirical studies find a positive impact.

Theory also suggests that health may be endogenous to labour supply. This is implied in the human capital theory of health. To improve or maintain health status, individuals need to invest in their health, which requires both time and material resources. The availability of resources may depend on the individual's labour force status (past and current). In addition, labour market activities may also have a direct impact on individual health. For example, boredom or general lack of activity in non-participation may lead to a deterioration of health (Stern, 1989; Sickles and Taubman, 1986). Alternatively, it is also possible that stress associated with employment leads to health deterioration. In addition, some jobs may have bad working conditions and are harmful to health. Thus, in theory labour force participation could also affect health. But the direction of the impact is ambiguous.

2.2. Measurement of health status

Chirikos (1993) suggests that to establish the relationship between health and labour market behaviour, the health status must be suitably measured. That is, the measure used must be valid and reliable in the sense that it provides a comparable yardstick for measuring health differences over time and across individuals. However, in practice this criterion has not yet been met, there is still no common measure of health status which is utilised by different researchers. This may be due to the fact that health status is not one dimensional. Studies interested in different issues may need to focus on different dimensions of health. This diversity in health measures is also a problem for the issue we look at in this paper. Specifically, the estimated effect of health on labour supply varies greatly because different researchers use different measures of health and the estimates are sensitive to the health measures used (Currie and Madrian 1999). Generally speaking, the health effect is larger when self-assessed health variables are used and smaller when specific impairment, functional limitations, or mortality experience indices are used (Chirikos, 1993).

Summarising the literature on this issue, there are no perfect measures of health to be used for estimating the effect of health on labour supply.[2] There are arguments for and against using self-assessed health. Although there is a rationalisation endogeneity concern over self-assessed health, the empirical evidence on its existence is neither strong nor consistent with the hypothesis in the literature. As a result, the use of self-assessed health in estimating the effect of health on labour force participation is still popular in the literature.

2.3. Modelling strategies

As discussed in the section 2.1, rationalisation endogeneity is not the only source of endogeneity. Even if we do have a true and objective measure of health, theory suggests that this measure may still be endogenous to the labour supply decision. To account for the endogeneity of health to labour force participation, we estimate the health equation and labour force participation equations simultaneously. The modelling strategies draw on Stern (1989) and are briefly described in this section.

[2] See Appendix 1 for a discussion of the literature on this issue.

The model specifications are presented in the next section. The first equation describes the determination of health:

(1) $h^{**} = \gamma_1 l^* + x_1\beta_1 + \varepsilon_1$

where h^{**} is the latent true health which depends on the latent inclination to participate in the labour force (l^*) and a set of exogenous variables, x_1. Latent labour force participation enters equation (1) because of the endogeneity of true health. The rationalisation endogeneity is not accounted for in equation (1) because this equation is about the determination of true health, not self-assessed health.

The labour force participation equation is specified as

(2) $l^* = \gamma_2 h^{**} + x_2\beta_2 + \varepsilon_2$

where the latent value of being in the labour force relative to being out of the labour force is determined by true health h^{**} and a set of exogenous variables x_2. x_1 and x_2 may have some variables in common.

Because true health is not observed, we need another equation to relate true health and the observed self-assessed health, which is:

(3) $h^* = h^{**} + \alpha l^* + \omega$

where h^* is the latent measure of self-assessed health status, which depends on true health and labour force participation. The dependence of self-assessed health on labour force status reflects the rationalisation endogeneity of self-assessed health. A positive α implies that those in the labour force tend to overstate their health and those not in the labour force tend to understate their health. The three disturbance terms, ε_1, ε_2 and ω, are assumed to be independent of each other.

Substituting equation (1) into equation (3), gives:

(4) $h^* = \theta_1 l^* + x_1\beta_1 + \varepsilon_h$

where $\theta_1 = \gamma_1 + \alpha$, and $\varepsilon_h = \varepsilon_1 + \omega$. In the model, only θ_1 can be identified; γ_1 and α cannot be estimated separately. This means that true endogeneity and rationalisation endogeneity cannot be separated.

From (3), it follows that $h^{**} = h^* - \alpha l^* - \omega$. Substituting this into (2) gives:

(5) $l^* = \theta_2 h^* + x_2\beta_l + \varepsilon_l$

where $\theta_2 = \dfrac{\gamma_2}{(1+\gamma_2\alpha)}$, $\beta_l = \dfrac{\beta_2}{(1+\gamma_2\alpha)}$, and $\varepsilon_l = \dfrac{(\varepsilon_2 + \gamma_2\omega)}{(1+\gamma_2\alpha)}$.

ε_h and ε_l are correlated through ω, even if ε_1 and ε_2 are assumed independent[3].

The corresponding observed values of the endogenous variables are:

$$(6)\ h = \begin{cases} 4 & (= excellent) & if \quad m_3 < h^* < m_4 = +\infty \\ 3 & (= very\ \ good) & if \quad m_2 < h^* \le m_3 \\ 2 & (= good) & if \quad m_1 < h^* \le m_2 \\ 1 & (= fair) & if \quad m_0 < h^* \le m_1 \\ 0 & (= poor) & if \quad -\infty = m_{-1} < h^* \le m_0 \end{cases},$$

$$(7)\ l = \begin{cases} 1 & (= in\ \ labour\ \ force) & if \quad l^* > 0 \\ 0 & (= not\ \ in\ \ labour\ \ force) & if \quad l^* \le 0 \end{cases}.$$

Equations (4), (5), (6) and (7) constitute a simultaneous equation system. The coefficient parameters to be estimated are $\theta_1, \theta_2, \beta_1, \beta_l$ in equations (4) and (5). To identify these coefficients, standard conditions for simultaneous equation models need to be satisfied. We implement these conditions by including different variables in x_1 and x_2. Based on (6) and (7), equation (4) is essentially an ordered probit model and equation (5) a probit model. Therefore, θ_1 and β_1 can only be identified up to a factor which is the inverse of the standard deviation of ε_h. Similarly, θ_2 and β_l are identified up to a factor which is the inverse of the standard deviation of ε_l (Maddala, 1983).

[3] ε_1 and ε_2 are highly likely to be correlated because there may be some unobservable factors that affect both health and labour force participation.

The maximum likelihood method is used to estimate the parameters in equations (4) and (5) simultaneously. We assume that ε_l and ε_h follow a standard bivariate normal distribution with a correlation coefficient ρ which is also to be estimated. Because we take into account the correlation between the error terms in the two structural equations, this method is called full information maximum likelihood method (Greene, 1993). Define

$P_{i,mn} = \Pr(h = m, l = n)$ for observation *i*,

$$d_{i,mn} = \begin{cases} 1 & if \quad h = m \quad and \quad l = n \\ 0 & otherwise \end{cases}, \text{ for } h = 0,\ 1,\ 2,\ 3,\ 4 \text{ and } l = 0,\ 1.$$

The log-likelihood function for the sample is[4]

$$(10)\ ll = \sum_{i=1}^{N} \sum_{m=0}^{4} \sum_{n=0}^{1} d_{i,mn} \log P_{i,mn}\ .$$

Although the modelling approach here is similar to Stern's (1989), Stern estimates the simultaneous equations using the FIML method when both the self-assessed health variable and labour force participation variable take a dichotomous form, but when he allows the health variable to take a polychotomous form, he uses a two-stage estimation method. In the first stage the reduced form equations are estimated using ordered probit and probit. Using the parameter estimates from the first stage, the latent indices for health and labour force participation are predicted. At the second stage the predicted values of health and labour force participation are substituted into the structural equations (equations (4) and (5)); ordered probit and probit are again applied to the structural equations to estimate the required parameters. The two-stage estimation method is essentially an instrumental variable method, where all exogenous variables are used as instruments to estimate each equation in the system separately. The two-stage estimation method produces consistent parameter estimates, but it is not efficient because the potential correlation between the error terms in the structural equations is not taken into account.

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[4] See Appendix 1 for detailed probability definitions. Standard econometric packages, such as STATA and SAS do not provide this type of model. Therefore, we have written a GAUSS programme to estimate the model.

The FIML estimation method employed in this paper explicitly takes into account the correlation between the two error terms in equations (4) and (5) and the estimation results are thus consistent as well as efficient. Another advantage of the FIML method is that the significance of the coefficient on the labour force participation variable and the correlation coefficient between the two error terms can be jointly tested. This is a true test of the exogeneity hypothesis. In contrast, in the two-stage method, exogeneity can only be partially tested. This is because in the two-stage method only the coefficient on the labour force participation variable is estimated and the correlation coefficient is assumed zero. Exogeneity can only be tested based on the significance of the labour force participation variable.

3. Data and model specification

3.1. The data

The data used for this paper come from the first wave of the Household, Income and Labour Dynamics Australia (HILDA) Survey. Details of this survey are documented in Watson and Wooden (2002). The survey selected a nationally representative sample of Australian households. For each selected household, an interview was conducted with at least one adult member regarding the household. Then individual interviews were undertaken with all the household members who were aged over 15 years on the 30 June preceding the interview. In addition to the data collected through personal interviews, each person completing a personal interview was also given a self-completion questionnaire to be returned on completion by mail or handed back to the interviewer at a subsequent visit to the household. Almost all interviews were conducted in the period between 24th August 2001 and 21st December 2001.

The HILDA dataset contains detailed information on individuals' labour market activity and history, such as years in paid employment, unemployment and out of the labour force since the first time leaving full-time education. This provides us with the opportunity to examine whether past employment and unemployment have an impact on current health status and labour force participation[5]. For those currently employed,

[5] Ideally, time out of labour force should also be included in the model. But this variable is contaminated in the sense that HILDA does not distinguish between the time spent on education when out of the labour force and other time out of the labour force. The impacts of the time on education and

information about characteristics of their main job (such as occupation, hours and tenure) and their employer (industry, size and sector) were also collected. For those not in paid employment, questions such as reasons for not working, job search activity, industry and occupation in their last job and reservation wage were asked.

Information relating to individual health was collected in both the personal interviews and self-completion questionnaires. In the personal interviews, a standard self-assessed health status question (5 levels scaled from poor to excellent) was first asked. Then individuals were asked whether they had a long-term condition, impairment or disability which restricted everyday activities and had lasted or was likely to last for six months or more. For those who had a long-term condition, impairment or disability, three follow-up questions were asked: whether the condition or disability limited the type of work or the amount of work; how much the condition or disability limited work; and whether the condition or disability first developed in the last 12 months.

In the self-completion questionnaire, the Short Form 36 health status questions (SF-36) were asked. The SF-36 is a measure of general health and wellbeing, and produces scores for eight dimensions of health (Ware et al. 2002). The first question in the SF-36 is the same as the first health question asked in the personal interviews. Unfortunately, the responses to the same health question are not identical for all persons who provided an answer to both the personal interviews and the self-completion questionnaire. The question arises of which self-assessed health variable is to be used in the model estimation. We chose the response in the self-completion questionnaire for the following three reasons. First, individuals may be more candid to sensitive questions, such as health status, when filling out a self-completion form rather than being interviewed (Tourangeau and Smith, 1996). Second, in the personal interview, persons were asked several labour market related questions before being asked the health questions. The answers to the labour market questions may have had an impact on their responses to the health questions. In particular, the effect of rationalisation of self-assessed health status may be stronger in responses to the health questions asked by the interviewer than in the self-completed questionnaire. Third, the

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the time really out of the labour are very different. The real time out of the labour force cannot be generated from the data.

second set of responses could be more accurate in the sense that people may have learned through answering the first set of health-related questions.

Before describing the variables included in the model, we tabulate the labour force status against self-assessed health status by gender and age groups in Table 1. Those who are still at school or undertaking full time study are excluded from the sample. People over age-pension age are also excluded[6]. A positive (negative) relationship between labour force participation (non-participation) and health status appears from the simple tabulation. Specifically, the proportion of persons not in the labour force decreases with health. That is the better their health, the more likely a person is to be in the labour force. For example, while about 70 percent of males reporting poor health are not in the labour force, only 6 percent of males reporting very good health are not in the labour force. For all five self-assessed health categories, older males are more likely not to be in the labour force than younger males. Nevertheless, the positive relationship between health and labour force participation appears for both younger and older males. Females show a similar pattern, except that for all health categories, females have a lower labour force participation rate than males, which is consistent with other survey data.

The negative relationship between health and age can also be inferred from Table 1. While about 11 percent of males aged 15 to 49 report fair or poor health, over 24 percent males aged 50 to 64 do so. Similarly, for females, about 11 percent aged 15 to 50 report fair or poor health, while 20 percent aged 50 to 60 do so.

Finally, the HILDA survey also asked those who were not employed the reasons for ceasing their last job. This shows a substantial proportion ceased work for health reasons. Among working-age males who are not employed, over one third cited own illness or disability as the reason for ceasing their last job. Subdividing this group by age, 39 percent of those aged 50 to 64 and 29 percent of those aged 15-49 indicated that own illness or disability was the reason for ceasing their last job. Among females aged 15 to 50, 14 percent cited own illness or disability as the reason for ceasing their last job, whereas for females aged 50 to 60 this is 21 percent.

[6] Male age-pension age is 65. Female age-pension age is changing over time, but at the time of the interview was 61.

Table 1: Labour force status[a] by self-assessed health status[b]

	Excellent (4)	Very good (3)	Good (2)	Fair (1)	Poor (0)
Male					
% In labour force	92.97	94.24	89.53	66.29	32.00
% Not in labour force	7.03	5.76	10.47	33.71	68.00
Observations	740	1736	1499	534	150
Male aged 15-49					
% In labour force	96.15	96.82	94.5	82.58	43.11
% Not in labour force	3.85	3.18	5.51	17.42	56.9
Observations	598	1321	1071	310	58
Male aged 50-64					
% In labour force	79.58	86.03	77.11	43.75	25
% Not in labour force	20.42	13.98	22.9	56.25	75
Observations	142	415	428	224	92
Female					
% In labour force	78.65	77.86	69.35	51.90	26.83
% Not in labour force	21.35	22.14	30.65	48.10	73.17
Observations	862	1888	1527	499	123
Female aged 15-49					
% In labour force	79.46	78.46	72.34	59.34	37.18
% Not in labour force	20.55	21.55	27.66	40.66	62.82
Observations	730	1513	1157	332	78
Female 50-60					
% In labour force	74.24	75.46	60	37.13	8.89
% Not in labour force	25.76	24.53	40	62.87	91.11
Observations	132	375	370	167	45

a, In labour force includes employed and unemployed.

b, The values of the five self-assessed health levels are recoded as shown in the table.

3.2. Model specification

In this subsection we describe the exogenous variables included in both the health and labour force participation equations. Table 2 provides the definitions for all variables included in the model.

The identification condition for simultaneous equation models is satisfied because different independent variables are included in the two equations (Maddala, 1983). That is the variables included in the health equation but not in the labour force participation equation identify the labour force participation equation; and the variables included in the labour force participation equation but not in the health equation identify the health equation.

Table 2: Variable definitions

Endogeneous variables	
lf	1 if in labour force
health	self-assessed health status, 0=poor, 1=fair, 2=good, 3=very good, 4=excellent
Variables appearing in both equations	
Demographic	
age	age deviation from a base age. For the younger groups, this equals individual's age minus 15; for the older groups, this equals individual's age minus 50
married	1 if married or de facto
indig	1 if indigenous or Torres Strait Islander
Education	
degree	1 if has a bachelor or higher degree
oth_psq	1 if has other non-degree post-school qualifications
yr12	1 if completed year 12
Job history and spouse's labour force status	
sp_lf	1 if married and the spouse in LF
em_lif	proportion of life (since leaving school) in employment
unem_lif	proportion of life (since leaving school) unemployed
Additional variables appearing in the labour force participation equation	
Demographic	
age_2	age deviation squared (a)
cob_os	1 if born overseas
cob_n_en	1 if born in non-English speaking foreign country
chld04	1 if has child(ren) under 4 years of age
chld514	1 if has child(ren) aged 5 to 14
chld014	1 if has child(ren) aged 0 to 14 (b)
mar_04	interaction between married and chld04
mar_514	interaction between married and chld514
mar_014	interaction between married and chld014 (b)
Additional variables appearing in the health equation	
Occupation	
trade	1 if last or current job as a tradesperson or related worker
cle_s	1 if last or current job as a clerical, sales or service worker
prd_tr	1 if last or current job as a production or transport worker
labour	1 if last or current job as a labourer or related worker
oth_occ	1 if last or current job in an occupations other than trade, cle_s, prd_tr and labor
nev_w	1 if never worked (d)
Health related	
smok	1 if currently smoking or ever smoked
condi	1 if has long-term health conditons
no_act	1 if lack of physical activity, defined as no physical activity at all or less than once per week
drink	1 if a heavy drinker, defined as drinking more than 6 standard drinks a day when drinking
pf_ind	Index of physical functioning

Note a: The age variable enters the model as a deviation. For the younger groups, the difference between the actual age and 15 enters the model estimation. For the older groups, the difference between the actual age and 50 enters the model estimation. A similar deviation applies to the age squared variable.

b: The reason that *chld014* and *mar_014* are used for older people in place of *chld04, chld514, mar_04,* and *mar_514* is that among the older age groups, few people have a child younger than 5 years of age. There are no males aged 50 or over having a child younger than 5 years. Only a few females aged 50 or over have a child younger than 5 years.

d: The variable, nev_w, is excluded from the health equation for older men, because only one person has never worked in this group. This observation is excluded from estimation.

The variables included in the labour force participation equation are standard in the literature. However, for the health equation, some justifications may be needed for the inclusion of some of the variables listed above. Age is included because it is often observed that health deteriorates with age (Kenkel, 1995). Australian survey data show that the disability incidence rate increases with age (ABS, 1998). It is also found that people aged 50 and over have a higher probability of entering the Disability Support Pension (DSP) program than people under 50 years of age (Cai and Gregory, 2003). It has long been noticed that health and marital status have a close relationship (see, for example, Beckett and Elliott (2002), and references quoted there). Although there are different hypotheses about the mechanism through which this relationship is established, health is often seen to be positively correlated with being married. Education may improve health through enhanced awareness of health-related knowledge. In addition, it may serve to help control for the impact of parental socio-economic status (SES) on an individual's health since individual educational achievement is greatly influenced by the parents' SES.

To explain the difference in self-assessed health status between individuals, it would be ideal to have some specific and objective health indicators in the health equation, such as symptoms, types and severity of disabilities or health conditions. Unfortunately, such detailed measures are not available in the HILDA survey. However, two summary indicators of health problems are available in the data and are included in the health equation. The first is the existence of long-term health conditions (*condi*). This variable is included although it is self-reported, following a suggestion by Bound et al. (1995) that it is reasonable to treat self-reports of chronic health conditions as exogenous. The variable, *condi*, is used here in a similar way to Stern (1989). The difference is that Stern (1989) includes a list of specific long-term health conditions in his health equation, while we only have a summary indicator. The second is one of the SF-36 indices, the index for physical functioning (*pf_ind*). Because this index is constructed based on individuals' answers to the questions about specific physical functioning limitations, such as climbing one flight of stairs, lifting or carrying groceries, or bending, kneeling or stooping, it can be treated as an exogenous variable[7]. By including the above variables (which are assumed to be exogenous to labour force participation) in the health equation we are talking about the component of health that is unlikely to be influenced by current labour force participation. Controlling for these conditions will result in a better estimate of the feedback effect of labour force participation. We now compare the health of someone with a long-term health condition who is in the labour force with someone who also has a long-term health condition but is not in the labour force.

By including the smoking (*smok*) and the lack of physical activities (*no_act*) variables in the health equation only, we assume that they affect labour force participation only through their impacts on health. The impact of unemployment on health has been discussed frequently (Wilson and Walker, 1993; Mathers and Schofield, 1998) and is included here as well. The inclusion of the employment history variable (*em_lif*) can also be justified in theory although its effect is not predicted unambiguously. On the one hand, employment may put stress on individuals or bad work conditions may be harmful to health; on the other hand, employment may make people happier and enhance self-confidence which could have a positive effect on health. In addition, wealth and income, which are important factors in health determination, depend to some extent on employment experience. Family income and wealth also depend on the spouse's employment and furthermore the spouse's participation in the labour force may release pressure from the individual. Therefore, the spouse's labour force participation could have an impact on an individual's health status. The occupation variables are included to control for impacts of "bad" jobs on health. n*ev_w* is included to indicate those who have never worked and have therefore no an occupation.

Table 3 presents variable means for the samples used in the analysis. As implied earlier, we estimate the model for males and females separately; and each gender is divided into two age groups: those aged 15 to 49 and those aged 50 to age-pension age. Therefore, the sample means are presented for these four groups. The sample used for estimation is smaller than that presented in Table 1 because individuals who have a missing value in any of the variables included in the model are excluded.

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[7] Bound, Schoenbaum and Waidmann (1996) argue that survey questions that are more specific and concrete should be less subjective and therefore less susceptible to the rationalisation endogeneity problems.

Table 3: Descriptive statistics of the sample								
	Males 15-49		Females 15-49		Males 50-64		Females 50-60	
Variable	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Endogeneous variables								
lf	0.94	0.23	0.75	0.43	0.71	0.45	0.62	0.49
health	2.63	0.93	2.65	0.95	2.24	1.07	2.38	1.01
Demographic								
age	35.02	8.73	34.91	8.47	56.43	4.24	54.57	3.11
married	0.65	0.48	0.68	0.47	0.81	0.39	0.74	0.44
chld04	0.22	0.41	0.25	0.43	0.02	0.13	0.00	0.03
chld514	0.30	0.46	0.39	0.49	0.09	0.29	0.05	0.22
chld014	0.43	0.50	0.53	0.50	0.10	0.30	0.05	0.22
mar_04	0.21	0.41	0.21	0.41	0.02	0.13	0.00	0.03
mar_514	0.29	0.45	0.32	0.47	0.08	0.28	0.04	0.19
mar_014	0.42	0.49	0.44	0.50	0.09	0.29	0.04	0.19
cob_os	0.21	0.41	0.21	0.41	0.33	0.47	0.29	0.45
cob_n_en	0.11	0.31	0.12	0.33	0.17	0.37	0.15	0.36
indig	0.02	0.12	0.02	0.16	0.01	0.09	0.01	0.10
Education								
degree	0.21	0.41	0.26	0.44	0.19	0.39	0.20	0.40
oth_psq	0.46	0.50	0.34	0.47	0.43	0.50	0.30	0.46
yr12	0.12	0.32	0.14	0.35	0.08	0.27	0.06	0.24
yr11_lo	0.21	0.41	0.26	0.44	0.30	0.46	0.44	0.50
Occupation, job history and spouse's labour force status								
trade	0.22	0.41	0.04	0.20	0.13	0.34	0.02	0.15
cle_s	0.14	0.34	0.44	0.50	0.14	0.35	0.40	0.49
prd_tr	0.13	0.33	0.03	0.17	0.14	0.35	0.05	0.22
labour	0.11	0.32	0.09	0.28	0.10	0.30	0.13	0.34
oth_occ	0.41	0.49	0.41	0.49	0.48	0.50	0.39	0.49
sp_lf	0.47	0.50	0.64	0.48	0.51	0.50	0.51	0.50
em_lif	0.87	0.21	0.71	0.29	0.93	0.12	0.66	0.28
unem_lif	0.05	0.13	0.04	0.12	0.02	0.05	0.01	0.04
nev_w	0.01	0.11	0.02	0.16			0.01	0.11
Health related								
smok	0.56	0.50	0.50	0.50	0.63	0.48	0.44	0.50
condi	0.17	0.38	0.14	0.35	0.35	0.48	0.28	0.45
no_act	0.23	0.42	0.29	0.45	0.28	0.45	0.28	0.45
drink	0.15	0.36	0.05	0.22	0.05	0.22	0.01	0.10
pf_ind	89.76	18.46	88.11	18.38	78.34	24.29	77.94	23.27
No of observations	3189		3410		1175		940	

Several prominent points appear from the descriptive statistics. The participation rate of older men is about one quarter lower than that of younger men, whereas the difference between older and younger women is smaller. As expected, for both men and women, the mean value of self-assessed health is lower for older people than for younger people. Very few older people have children under the age of 4. For both older men and women, a larger proportion is born overseas than for younger men and women. In general, younger people are more educated than older people. Women are more likely to have a degree than men are, but they are less likely to have other non-degree post-school qualifications than men are. Older women are more likely to have dropped out of school than older men. Men are more likely to be tradespersons or production and transport workers than women, while women are more likely to be clerical, sales or service workers than men. For younger people, spouses of women are more likely to be in the labour force than spouses of men. Although smoking is still dominated by men, the difference between younger men and women is very small. While older men are more likely to be smokers than younger men, younger women are more likely to be smokers than older women. Older men are more likely to have long-term health problems than older women. Heavy drinkers are more likely to be among younger men than any than groups.

4. Estimation results

Table 4 presents the estimation results for the four groups. The model is similar to a bivariate probit model, where the log-likelihood function is not globally concave because of the correlation coefficient between the two error terms (Greene, 1995: p 457). As a result, the choice of the starting values for the parameters becomes important. Following suggestions by Maddala (1983) and Greene (1995), we use the estimates from the two-stage method as starting values since they are consistent estimates. The magnitude of the coefficients is not directly comparable across groups because, as mentioned earlier, the coefficients are only identified up to a factor and the factors for different groups may not be the same. We first look at the estimates for the endogenous variable because they are the focus of our interest.

Table 4: Full imformation maximum likelihood results

	Males 15-49		Females 15-49	
	Coefficient	Standard error	Coefficient	Standard error
Labour force participation equation				
health	0.8034***	0.1132	0.3521***	0.0398
age/10	-0.1171	0.1608	-0.6316***	0.1817
age_2/100	-0.0018	0.0394	0.1374***	0.0450
degree	0.4566***	0.1529	0.5290***	0.0855
oth_psq	0.0632	0.1009	0.1946***	0.0710
yr12	0.2417	0.1673	0.0388	0.0949
married	-0.1052	0.1245	-0.5402***	0.1424
sp_lf	0.3547***	0.1253	0.4277****	0.1170
em_lif	2.0962***	0.2195	2.0245***	0.1216
unem_lif	1.5225***	0.3154	1.0777***	0.2415
indig	0.0066	0.4561	0.0814	0.1407
cob_os	-0.2603**	0.1032	-0.0955	0.0922
cob_n_en	-0.0062	0.1226	-0.0173	0.1130
chld04	-1.4037***	0.4944	-0.9899***	0.1282
chld514	-0.1877	0.2078	-0.3184***	0.1200
mar_04	1.5360***	0.5012	-0.1753	0.1438
mar_514	0.2185	0.2211	0.4434***	0.1316
cons	-1.4223***	0.3322	-0.2662	0.1840
Health equation				
lf	-0.6990***	0.1645	-0.0342	0.0381
age/10	-0.2513***	0.0456	-0.0614**	0.0244
degree	0.6475***	0.1297	0.1878***	0.0673
oth_psq	0.1905**	0.0796	0.1312**	0.0525
yr12	0.3981***	0.1314	0.1755***	0.0629
married	-0.0296	0.0897	0.0733	0.1081
sp_lf	0.3848***	0.1066	0.0725	0.1033
em_lif	1.9185***	0.3701	0.2879**	0.1172
unem_lif	1.1684***	0.3326	-0.0530	0.1630
indig	0.5961*	0.3419	-0.0549	0.0993
smok	-0.2455***	0.0483	-0.2796***	0.0388
no_act	-0.3511***	0.0548	-0.3812***	0.0419
drink	-0.1794***	0.0673	0.0699	0.0831
condi	-0.8955***	0.0687	-0.9159***	0.0549
pf_ind/100	1.6942***	0.1200	1.6863***	0.0905
trade	-0.0825	0.0691	-0.0738	0.1031
cle_s	-0.1373*	0.0735	-0.0516	0.0501
prd_tr	-0.1540*	0.0798	-0.2907***	0.1096
labour	-0.1406*	0.0826	-0.1096	0.0776
nev_w	0.0656	0.1941	-0.0543	0.1198
cut_1	-0.5398	0.3501	-1.3302***	0.1602
cut_2	0.4134	0.2553	-0.153	0.1462
cut_3	1.3951***	0.1942	1.1188***	0.1446
cut_4	2.3568***	0.2041	2.3477***	0.1431
ρ	-0.0044	0.1742	-0.2711***	0.0635
No of observations		3189		3410
Log likelihood		-4268.76		-5335.32

*** significant at 1%, ** 5%, * 10%.

Table 4: Full imformation maximum likelihood results (continued)				
	Males 50-64		Females 50-60	
	Coefficient	Standard error	Coefficient	Standard error
Labour force participation equation				
health	0.5530**	0.2800	0.4276***	0.0649
age/10	-0.8986***	0.1378	-0.8261***	0.1801
degree	0.5220***	0.1748	0.2223	0.1599
oth_psq	-0.0189	0.1225	-0.0258	0.1293
yr12	-0.1690	0.2301	0.1789	0.2035
married	-0.1630	0.1439	-0.9453***	0.1476
sp_lf	0.8570***	0.1224	1.0039***	0.1377
em_lif	7.3069***	0.518	2.2171***	0.2184
unem_lif	6.5844***	1.0703	1.7650*	1.0389
indig	-0.2832	0.4960	-0.0933	0.4883
cob_os	-0.0259	0.1176	-0.0178	0.1195
cob_n_en	0.1631	0.1624	-0.4269**	0.1718
chld014	-0.3920	0.3834	-0.3894	0.3176
mar_014	0.5025	0.4343	0.3772	0.3834
cons	-8.8459***	2.7508	-1.1854***	0.2162
Health equation				
lf	-0.5802	0.4553	0.3936**	0.1952
age/10	-0.3544	0.4666	0.3708*	0.2034
degree	0.7480***	0.2045	0.0878	0.1444
oth_psq	0.0672	0.1049	0.1982**	0.1000
yr12	0.0207	0.1877	0.0038	0.1623
married	-0.1929*	0.1116	0.2556	0.2447
sp_lf	0.5189	0.3913	-0.2024	0.2655
em_lif	4.7888	3.2053	-0.7216	0.4776
unem_lif	3.2628	3.3715	-0.2480	0.8314
indig	-0.5293	0.3271	0.1082	0.3700
smok	-0.2345***	0.0858	-0.1699***	0.0652
no_act	-0.2469***	0.0899	-0.1841**	0.0788
drink	0.2171	0.1562	0.1144	0.3323
condi	-0.9262***	0.2023	-0.4965***	0.1138
pf_ind/100	2.2823***	0.4886	2.3408***	0.4222
trade	-0.1174	0.1061	-0.0489	0.2317
cle_s	0.0061	0.0972	0.0358	0.0771
prd_tr	-0.2054	0.1094	-0.0813	0.1384
labour	-0.1318	0.1170	-0.2031*	0.1110
nev_w			0.1922	0.4016
cut_1	3.5723	3.1861	-1.1001***	0.3437
cut_2	4.5241*	2.7077	0.3307	0.3981
cut_3	5.5534**	2.1924	1.7299***	0.4657
cut_4	6.5312***	1.7070	3.0410***	0.5237
ρ	0.3479	0.5035	-0.6237***	0.1691
No of observations		1175		940
Log likelihood		-1722.10		-1439.56
*** significant at 1%, ** 5%, * 10%.				

4.1. The estimates for the endogenous variables

Overall, a significant impact of health on labour force participation is estimated. The positive sign indicates that, other things equal, better health increases the probability of labour force participation for all four groups. Due to the endogeneity of health we cannot calculate the marginal effect of health on labour force participation. To get a feeling for the effect, we predict the probabilities of labour force participation conditional on five ranges of latent health. The five ranges of latent health are defined by the estimates for the cut-off points in the health equation and correspond to the five health categories. The reported conditional probabilities in Table 5 are averages over the sample.[8]

Table 5: Predicted conditional probability of labour force participation

Health status	Predicted probability of LFP	% change compared with higher health status	% change compared with excellent health
Males 15-49			
Poor	0.9280	-0.7075	-2.4188
Fair	0.9346	-0.6220	-1.7235
Good	0.9405	-0.5646	-1.1084
Very good	0.9458	-0.5469	-0.5469
Excellent	0.9510		
Males 50-64			
Poor	0.6206	-6.9959	-20.8982
Fair	0.6672	-5.9806	-14.9481
Good	0.7097	-5.1719	-9.5380
Very good	0.7484	-4.6042	-4.6042
Excellent	0.7845		
Females 15-49			
Poor	0.7193	-1.7640	-6.5388
Fair	0.7322	-1.6945	-4.8605
Good	0.7449	-1.5964	-3.2207
Very good	0.7569	-1.6506	-1.6506
Excellent	0.7696		
Females 50-60			
Poor	0.5139	-8.7908	-25.3216
Fair	0.5634	-7.2959	-18.1241
Good	0.6077	-6.2596	-11.6803
Very good	0.6483	-5.7828	-5.7828
Excellent	0.6881		

[8] We also computed the conditional probabilities of labour force participation by observed self-assessed health status. As expected, we found that the conditional probabilities increase with observed health status, indicating that those who have better health also have other individual or household characteristics that increase the probability of labour force participation.

Table 5 shows that the impact of health on labour force participation is larger for older people than for younger ones. For instance, for an older man a deterioration of health from good to fair reduces the probability of labour force participation by nearly 7 percent. For a younger man, the same change in health reduces the probability of labour force participation by less than 1 percent. The differences in the effect of health on labour force participation between older and younger people are as expected. It also appears that for the same age group the impact is somewhat larger for females than for males. This is also according to expectations.

The feedback effect of labour force participation on health is not so clear. For younger males, labour force participation is estimated to have a significant negative impact on health status, but the estimated impact is not significant for older males and younger females although the sign is also negative. For older females the estimated effect of labour force participation on health is positive and significant. Rationalisation endogeneity of self-assessed health to labour force participation implies that in the health equation the coefficient on labour force participation would be positive. The negative sign for males and younger females suggests that the rationalisation endogeneity, if it exists, may be small and outweighed by the effects of other factors. Specifically, the significant and negative impact of labour force participation on younger males' health suggests that "bad work conditions" or "work stress" effects dominate other positive effects of labour force participation. This finding is similar to Stern (1989). The insignificance of the negative impact of labour force participation on health for older males may be due to a self-selection process: those older males who choose to remain in the labour force may have a position which has little or no "bad work conditions" effect; or they are so healthy that the "bad work conditions" or "work stress" effect does not have an adverse impact on their health.

The positive sign of the labour force participation variable in the health equation for older females indicates that rationalisation endogeneity may occur to older females' self-assessed health. This is a surprising result because women are normally under less pressure socially than men to attribute non-participation to ill health. Indeed, using data from the National Survey of Families and Households and from the Survey of Income and Program Participation, Ettner (1997) finds that among women, self-assessed measures of health are not affected by employment status. Therefore, the positive sign for older females may not be due to rationalisation endogeneity. Rather, this may be due to self-selection into labour force status and the selection of jobs by older women. That is those older women who are in the labour force are in very good health and they have jobs that are less likely to harm their health.

4.2. The labour force participation

Looking at the estimation for the labour force participation equation, the sign of the age variable is as expected: the probability of labour force participation decreases with age. The age-squared variable is included in the labour force participation equations for younger people and it is only significant for younger females. For the educational variables, the omitted category is those who have not completed year 12. For young males and females and for older males, the educational variables are jointly significant at the 5 percent significance level, while they are not jointly significant for older females. For younger people, all the educational variables have expected signs. The sign on the variable, *oth_psq*, for both older males and females and the sign on the variable, *yr12*, for older females are opposite to expectation, but they are not significant.

The variable, *sp_lf*, is in fact an interaction term between being married and the variable "spouse in the labour force". This means that the coefficient on the marital status variable, *married*, measures the difference between being married to a spouse who is not in the labour force and being single. The negative sign indicates that a married person whose spouse is not in the labour force, is less likely to be in the labour force compared to a single person, perhaps because of the implied incentive effects of the income support system. This variable is only significant for females, which is according to expectations: a married female whose husband is not in the labour force is unlikely to be in the labour force. The coefficient on the variable, *sp_lf*, compares persons who are married to spouses in the labour force with those married to spouses not in the labour force. This variable is significant for all four groups with a positive sign, implying men and women married to a spouse in the labour force have a higher probability of participation, compared with men and women whose spouses are not in the labour force. This is as expected for males. There are few households where only the wife participates in the labour force. An explanation for the positive effect for men and women may lie in marriage selection (or matching) process – a woman tends to marry a man who has similar characteristics to her in terms of ability and work motivation. The coefficients on the variables, *married* and *sp_lf*, need to be combined in order to compare those married to a spouse in the labour force with a single person. It appears that men and older women whose spouses participate in the labour force are more likely to be in the labour force than a single person. However, for younger women, due to the large negative coefficient on the marital status variable, the combination of the two coefficients implies that a younger woman whose spouse is in the labour force is less likely to be in the labour force than a single younger woman. These results are according to expectations.

Past labour force participation is apparently important to explain current participation. However, theoretically, the sign of the employment history variable is ambiguous. On the one hand, the longer one has been employed, the more income one has earned and the person could prefer to consume more leisure now. This is the income effect. On the other hand, the longer one is employed, the more experience one has and the higher the earnings the person can command. As a result, the person could be less likely to want to leave the labour force. This is the opportunity cost effect. The estimated sign on this variable indicates that employment history has a positive impact on labour force participation for all groups. The opportunity cost effect dominates the income effect. Theoretically, the unemployment history has an ambiguous impact as well due to a similar line of argument. The estimated result indicates that the income effect dominates the opportunity cost effect.

Older females from non-English-speaking overseas countries are less likely to participate than their counterparts from English-speaking overseas countries. For older women this effect is not significant. Language problems may be an obstacle to labour force participation. For men the estimation results for the country of birth variables are more difficult to explain. It is hard to interpret the result that younger males from English-speaking overseas countries are less likely to participate than younger males born in Australia.

All presence-of-a-child variables have the expected signs, but they are not significant for older males and females, possibly because very few older people in the sample have a child under 14 years of age, let alone a child under 5 years of age.

4.3. The health equation

In the literature on the effect of health on labour force participation, the determination of health is not the focus. The health equation, if it is estimated, is to account for the endogeneity of self-assessed health to labour force participation (e.g., Stern, 1989), or to construct a health index to be used in the labour force participation equation (e.g. Campolieti, 2002). Here the main aim of estimating the health equation is also to control for the endogeneity of the health variable. So we only briefly discuss the estimation results for the health equation.

What is common to all four groups is that the smoking variable (*smok)*, whether has a health condition variable (*condi*), the lack of physical activity variable and the physical functioning limitation variable (*no_act*) are all significant and have the expected signs. The age variable is significant for younger persons. The sign indicates that for younger persons their health deteriorates with age. This variable is not significant for older males, although it has the expected sign. For older females, the age variable has a positive sign and the coefficient is weakly significant. This is a surprising results and difficult to explain. The heavy drinking variable is only significant for younger males with the expected sign. It is not significant for other groups and its sign is also opposite to expectation. This is perhaps because the proportion of heavy drinkers in the three groups is very small as shown in Table 3.

For all four groups, the educational variables have the expected sign. Again, these variables are jointly significant for males and younger females, and insignificant for older females. For the younger groups, each educational variable is significant. For older males only the degree variable is significant, while for older females only the other non-degree post-school qualification variable is significant.

The interaction term between the marital status variable and the spouse's labour force participation variable is significant for younger males and the positive sign implies that married younger men whose spouses are in the labour force have better health than younger men whose spouse are out of the labour force. This is perhaps because there is less pressure on a man if his spouse is working than if his spouse is not. However, this variable is not significant for other groups.

The employment history variable is significant for younger people and has a positive sign, implying employment experience increases the health of younger people. It is surprising that the labour force participation variable and the employment history variable have an opposite sign and both are significant in the health equation for younger men. Theoretically, one would expect the same sign: if past employment is good for health, current labour force status should have a positive impact on health too. However, we do not control for the effect of past health on past labour force participation. One explanation could be that an individual’s employment experience was determined by the person’s past health status and the employment history variable could in part reflect individuals’ past health. Specifically, the fact that an individual spent a smaller proportion of his life since leaving full-time education in employment could indicate that the person might have a health problem. To the extent that current health and past health are correlated, the employment history variable will have a positive sign, although current labour force participation could be bad for health.

Finally, the occupational variables have in general expected signs, indicating that compared with jobs in occupations as a manager, an administrator, a professional or an associate professional, jobs in the occupations included in the health equation are “bad” for individuals’ health.

4.4. Two-stage estimation results

To compare the differences of the results between the two-stage method and the FIML method, we also carried out the two-stage estimation, which is reported in Appendix 2.[9] The differences between the two sets of results are notable in the health equation for younger males. For some variables, such as *lf, degree, oth_psq* and *yr12* in the health equation for younger males, the magnitude of the coefficients changes considerable. While the variable, *indig*, in the health equation for younger males is significant in the two-stage estimation, it becomes weakly significant in the FIML estimation

[9] Because the predicted value is used in the second stage estimation, the conventional method to compute the variance-covariance matrix of the estimates is on longer correct (Maddala, 1983). Although there is a way to correctly calculate the variance-covariance matrix (Amemiya, 1978, 1979), it is difficult to carry out. Instead, the standard errors reported in the table are approximated by bootstrapping using 1000 replications.

A surprising difference is the labour force participation variable in the health equation for younger males. While the variable is significant in the FIML estimation, the two-stage method produces a coefficient which is insignificant and much smaller in magnitude. The insignificance of the labour force participation variable in the two-stage method may be because of the lack of variation in the predicted value for the labour force participation variable. The predicted value is calculated from the first-stage estimation of the reduced-form labour force participation equation using probit. A feature of the probit model is that it tends to overpredict the event which is dominant in the sample. As shown in Table 3, 94 percent of younger males are in the labour force. The predicted participation rate from the first-stage estimation is even higher. As a result, the variation of the predicted value for the labour force participation variable is too small[10], which makes it difficult to identify its effect in the second stage. In contrast, the FIML method does not depend on the predicted value for labour force participation. This suggests that the FIML estimation method may be more appropriate to study the relationship between health and labour force participation for some groups.

4.5. Test for exogeneity

If self-assessed health is exogenous to labour force participation, both the coefficient on the labour force participation variable in the health equation (θ_1) and the correlation coefficient between ε_h and ε_l (ρ) should be zero. Hence, the null hypothesis for exogeneity is

$$H_0: \ \theta_1 = 0, \ \ and \ \ \rho = 0;$$

$$H_A: \ \theta_1 \neq 0, \ \ or \ \ \rho \neq 0.$$

The Wald-test statistics for testing the joint significance of θ_1 and ρ are reported in Table 6. For the older male group, although θ_1 and ρ are not significant individually, they are jointly significant. Overall, the test results show that for all four groups, the exogeneity hypothesis is rejected. This result is quite different from the two-stage estimation, where only for older females the exogeneity hypothesis is rejected.

[10] Indeed, the variation coefficient of the predicted value for the labour force participation variable is much smaller for younger males than for the other three groups.

Because the correlation coefficient between the two error terms, ε_h and ε_l, cannot be estimated from the two-stage method, inference on exogeneity can only be based on the significance of the coefficient on the labour force participation variable in the health equation.

Table 6: Test for exogeneity

	Males 15-49	Females 15-49	Males 50-64	Females 50-60
$\chi^2(2)$	58.39	35.09	12.92	30.94
Note: All statistics are significant at 5 percent level.				

4.6. Comparison to other studies

As mentioned earlier, the estimated effects of health on labour force participation are quite different across studies. This is mainly because authors use different measures of health[11]. This situation makes comparison between studies difficult. In addition, the majority of other studies in the literature used a dichotomous disability status as the measure of health, while in this paper the health variable takes a polychotomous form. Stern (1989) used a dichotomous and a polychotomous measure of health, but his scale when the health variable takes the polychotomous form is different from the scale used in this paper. In addition, his results came from the two-stage method and his samples are different from our samples. In his two samples, one for the group aged between 25 and 60 and the other for the group aged between 25 and 65, he pooled data on males and females in estimation. Therefore, our results on the impacts of health on labour force participation are not directly comparable with Stern's (1989). However, in terms of the health endogeneity issue, we have a similar finding to Stern (1989). That is the direction of the bias from endogeneity is opposite to the hypothesis in the literature, especially for the case of younger males.

It is also worth noting that Stern (1989) only finds the existence of endogeneity in his estimation using the FIML method. The fact that he did not find evidence of endogeneity when health takes a polychotomous form might be because he used the two-stage estimation method which ignores the correlation between the two error terms in the structural equations.

[11] Table 4 in Currie and Madrian (1999, p3334) provides a summary on the measures used in different studies on the effects of health on labour participation in the US.

The relationship between health and labour force participation appears to be different in different age-gender groups. Stern (1989) does not estimate the model separately for different age-gender groups. When we pooled the four groups, the labour force participation variable was not significant in the health equation when using the two-stage method, indicating exogeneity cannot be rejected. However, when we used the FIML method for the pooled sample, the joint test showed that exogeneity hypothesis was rejected, even though the coefficient on the labour force participation variable was insignificant. These may suggest that the weak evidence of exogeneity in Stern (1989) is due to his use of the two-stage estimation method.

5. Conclusion

This paper has examined the relationship between health and labour force participation using data from the recently released HILDA Survey. The potential endogeneity of the self-assessed health variables in the labour force participation equation is addressed by estimating the health equation and the labour force participation equation simultaneously. We take into account the correlation between the error terms in the two equations to obtain an efficient result. The estimation is conducted separately for males aged 50 to 64, males aged 15 to 49, females aged 50 to 60 and females aged 15 to 49.

Allowing for the endogeneity of health to labour force participation does not change the positive effect of health on labour force participation, which is found in other studies. This effect is found for all four groups. Also as expected, the predicted effect of health on labour force participation is larger for older people than for younger ones. However, the rationalisation endogeneity of the health to labour force participation is not confirmed by the results in this paper. In the health equation, the labour force participation variable is not significant for older males and younger females; it is only significant for older females. Although a strongly significant effect of labour force participation on health is estimated for younger males, the sign is opposite to the rationalisation hypothesis in the literature, which is a similar finding to Stern's (1989). A joint test for the significance of the labour force participation variable and the correlation coefficient between the two error terms indicates that exogeneity is rejected for all four groups. Therefore, although rationalisation endogeneity of self-assessed health is not a big issue for young females and older males, the existence of other sources of endogeneity may still bias the estimated effect of health on labour force participation if health is treated as an exogenous variable.

We also find that, when the labour force participation equation and the health equation are treated as a simultaneous system, the two-stage estimation method and the FIML method can produce quite different results. In particular, while the two-stage method produces an insignificant coefficient on the labour force participation variable in the health equation for younger males, the FIML method produces a significant coefficient, which is also bigger in magnitude. A possible explanation for this is that the two-stage method relies on the predicted values for the endogenous variables. The lack of variation in the predicted value may make the effect unidentifiable. This is particularly relevant for the group of younger males who have high labour force participation rates. Probit models tend to overpredict the occurrence of the more frequently observed outcome when the probability of this outcome gets closer to one. In addition, the FIML method is more efficient than the two-stage method and allows a joint test of the exogeneity hypothesis. For these reasons, the FIML method is preferred because the use of the two-stage approach may lead to incorrect conclusions in particular circumstances.

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Appendix 1: Literature review on the measurement of health status and its implications for estimating the effect of health status on labour force participation.

Currie and Madrian (1999) identify eight categories of health measures. These measures can be broadly classified into two groups: subjective measures and objective measures. The most common type of subjective measures is self-assessed health status derived from individuals' responses to survey questions such as "would you describe your health as excellent, good, fair, or poor?" or "Does your health limit the amount or kind of work you can do?" The presence of specific health limitations, disability, health conditions or symptoms, clinical assessment of physical or mental health, expected mortality or mortality experience, and various derived health status indices, such as body mass index (BMI), may be classified as objective measures.

In estimating the effect of health on labour force participation, several researchers raised a concern with regard to the use of self-assessed health (see, for example, Anderson and Burkhauser, 1984, 1985; Stern 1989; Bound, 1991; Dwyer and Mitchell, 1999; Kreider, 1999). First, self-assessed health may suffer from measurement errors. This is because individuals' awareness of health problems may vary with education, employment, income and health insurance status, and hence different individuals with identical health status may respond differently to the same health question. Second, self-assessed health may be used as a rationalisation for labour force status. For example, those not in the labour force may tend to report poor health to justify their non-participation. The consequence of rationalisation is that when self-assessed health is used in the labour force participation equation, the health variable becomes endogenous. Note that this endogeneity is different from that discussed in the previous subsection. Here the endogeneity occurs due to the use of the self-assessed health measure, whereas in the previous subsection it was suggested that health might be endogenous to labour supply, even if a true measure of health were used. We refer to the endogeneity associated with self-assessed health as rationalisation endogeneity. While the measurement error problems lead to a downward bias in the estimate of the impact of self-assessed health on labour force participation, the rationalisation endogeneity causes an upward bias. Third, as most health-related benefits, such as the disability support pension (DSP) in Australia, are based on the recipients having no capacity to work, there is an economic incentive for individuals to report poor health to qualify for such benefits. That is, individuals with a lower earning potential may be more likely to report poor health. This correlation may induce a bias in estimates of the impact of economic variables, such as earnings, on participation, when self-assessed health is also included as an explanatory variable (Bound, 1991).

Some studies have attempted to assess the potential bias in using self-assessed health status. For example, Bazzoli (1985) compares retirees' self-assessed health before and after retirement. She finds that the same individuals reported poorer health after retirement than before retirement and that self-assessed health after retirement had a statistically significant effect on the marginal probability of retirement; the pre-retirement self-assessed health did not. She concludes that the importance of self-assessed health is overstated in studies on early retirement. This finding is disputed by Boaz and Muller (1990). They also use the information on pre- and post-retirement self-assessed health, but focus on the difference in mortality experience and medical care utilization. If self-assessed health were an excuse for early retirement, this would most likely happen to those who report health problems only after retirement and there should not be a difference in mortality rates and medical care utilization between retirees who report health problems only after and not before retirement and retirees who do not report health problems before or after retirement. However, Boaz and Muller (1990) find that retirees who only report health problems after retirement have a much higher probability of early death and of hospitalization at the time of retirement than otherwise similar men who report no health problems. They conclude that early retirees who report health problems are indeed in poorer health and that the use of self-assessed work limitations as a health measure does not exaggerate the impact of health on labour force withdrawal.

Rationalisation endogeneity is based on the assumption that those who are out of the labour force might be more likely to report poor health to justify their non-participation. If this is the case, health status reported by workers should, on average, be more reliable than that reported by non-workers. Based on this argument, Kreider (1999) suggests that the "true" health status of non-participants can be constructed using information from participants. Specifically, he estimates a health equation using participants only (with a correction for selection). In the health equation, the dependent variable is the self-assessed health and the independent variables are specific health conditions and socio-economic factors. Using the estimated parameters, a health index for non-participants can be predicted and this index should, by assumption, be free of rationalisation bias. By comparing the predicted health index of non-participants with their self-assessed health, Kreider (1999) finds that non-participants tend to overestimate their health problems. However, the suspicion is that labour force participants may underestimate their health problems. For example, employment may make people feel better. In addition, it is also noted by Myers (1982) and Stern (1989) that workers may also assess their health status inaccurately. Therefore, self-assessed health from workers may not be more reliable than that from non-workers.

Although true health (if it is measurable and available in the data set) is also endogenous to labour force participation as discussed earlier, it is the rationalisation endogeneity associated with the self-assessed health variable that raises the major concern in estimating the effect of health on labour force participation. On this particular issue, it may be argued that the assumption underlying the rationalisation endogeneity of self-assessed health may not be quite correct. The rationalisation endogeneity of self-assessed health is based implicitly on the assumption that individuals first make a labour force participation decision, and then report a health status to justify that decision. However, it could also be the case that individuals first assess their health status and then formulate a strategy for modifying their labour market behaviour that accommodates their judgment (Chirikos, 1993). This argument is taken by Santiago and Muschkin (1996, p 304) for supporting their use of self-assessed health: "We were concerned about tapping into the effects of the cognitive dimension of disability. If individuals perceive themselves to be in poor health or unable to work, these perceptions may be the primary factors underlying labour market behaviours". In addition, Stern (1989) finds only weak evidence of endogeneity of the self-assessed health variable and the direction of bias due to endogeneity is opposite to the rationalisation hypotheses[12]. He concludes that bias due to potential (rationalisation) endogeneity is small. In a recent study by Dwyer and Mitchell (1999), which examines the effect of health on retirement plans, little

[12] The argument for rationalisation endogeneity is that those who are not in the labour force tend to overstate their health problems. Then labour force participation should have a positive impact on self-assessed health if the labour force participation is included in the (self-assessed) health equation as an independent variable. However, Stern (1989) finds, labour force participation has a negative effect on health.

evidence of the rationalisation endogeneity of self-assessed health to individuals' retirement plans is found. The authors also find little evidence of measurement error in either objective or subjective indicators of poor health.

In response to the potential problems associated with self-assessed health variables, several authors have used more objective health measures such as subsequent mortality (see, for example, Parsons (1982) and Anderson and Burkhauser (1984, 1985)) and specific health conditions to instrument self-assessed health (Stern, 1989; Bound, 1991; Campolieti, 2002). However, Bound (1991) shows that, as long as the objective measure , such as mortality, and the aspects of health that impact on labour supply (i.e., work capacity) are not perfectly correlated, the objective measure suffers from measurement error problems too. While the downward bias from measurement error and the upward bias from rationalisation endogeneity tend to cancel out when using self-assessed health measures, objective health measures only have a downward bias. These arguments are consistent with findings that the estimated impact of health on labour force participation tends to be smaller when objective measures are used than when self-assessed health measures are used. Therefore, an objective measure of health status, even if available in a dataset, is not free of problems. As for the instrumental variable approach, Bound (1991) notes that this approach does not itself solve the problem of endogenous self-assessed health.

In spite of these concerns, most studies that have included a disability measure to explain work decisions have employed individuals' self-assessed health as an explanatory variable (Kreider, 1999). Self-assessed health is still the most popular measure of health status and used as a true measure of health in many studies[13]. Furthermore, there are studies suggesting that self-assessed measures of health status are good indicators of health in the sense that they are highly correlated with medically determined health status (Nagi, 1969; Maddox and Douglas, 1973; LaRue et al., 1979; Ferraro, 1980). There are also studies showing that self-assessed health is a better predictor of mortality than some more objective measures of health status (Mossey and Shapiro, 1982; Idler and Kasl, 1995). Graur, West and Gregory (1988) find that self-assessed health helps to forecast a person's future health outcomes, such

[13] See, for example, Lee (1982), Chirikos and Nestel (1985), Anderson and Burkhauser (1984, 1985), Sickles and Taubman (1986), Haveman, Wolfe and Warlick (1984, 1988), Haveman, Wolfe, Kreider and Stone (1994), Stern (1989) and Kenkel (1995).

as morbidity and mortality. Tausman and Rosen (1982) find that self-assessed health is close to “objective” health. Idler and Benyamini (1997) find that in 23 out of 27 studies across 10 countries from 1982 to 1996, self-assessed health ratings “reliably predict survival in populations even when known health risk factors have been accounted for”. These studies lend credence to the usefulness of self-assessed health.

Appendix 2: **Probability definitions**

This appendix presents the detailed probability expressions to be used in the construction of the likelihood function.

The reduced forms of equations (4) and (5) can be written as:

$$h^* = \frac{1}{1-\theta_1\theta_2}[x_1\beta_1 + x_2\beta_l\theta_1 + (\varepsilon_h + \theta_1\varepsilon_l)] = x^*\pi_1 + \varepsilon_1^*, \text{ and}$$

$$l^* = \frac{1}{1-\theta_1\theta_2}[x_1\beta_1\theta_2 + x_2\beta_l + (\varepsilon_l + \theta_2\varepsilon_h)] = x^*\pi_2 + \varepsilon_2^*$$

where $x^*\pi_1 = \frac{1}{1-\theta_1\theta_2}[x_1\beta_1 + x_2\beta_l\theta_1)]$, $\varepsilon_1^* = \frac{1}{1-\theta_1\theta_2}(\varepsilon_h + \theta_1\varepsilon_l)$,

$x_2^*\pi_2 = \frac{1}{1-\theta_1\theta_2}[x_1\beta_1\theta_2 + x_2\beta_l)]$, and $\varepsilon_2^* = \frac{1}{1-\theta_1\theta_2}(\varepsilon_l + \theta_2\varepsilon_h)$.

Due to the terms, ε_l and ε_h, the covariance of the two error terms in the reduced-form equations, ε_1^* and ε_2^*, is determined by assumptions on ε_l and ε_h. We assume ε_l and ε_h to follow a standard normal bivariate distribution with a correlation coefficient ρ. Then ε_1^* and ε_2^* follow $N(0,\Omega)$, where

$$\Omega = \begin{bmatrix} 1 & -\theta_1 \\ -\theta_2 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \left(\begin{bmatrix} 1 & -\theta_1 \\ -\theta_2 & 1 \end{bmatrix}^{-1} \right)^T .$$

Denote the variances of ε_1^* and ε_2^* by σ_1^2 and σ_2^2, respectively, and their correlation coefficient by ρ^*, then the probabilities are as follows:

Probability of poor health and non-participation:

$$P_{00} = \Pr ob(h = 0, l = 0) = \Phi_2((m_0 - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2,\ \ \rho^*)\ .$$

Probability of poor health and participation:

$$P_{01} = \Pr ob(h = 0, l = 1) = \Phi((m_0 - x^*\pi_1)/\sigma_1) - \Phi_2((m_0 - x^*\pi_1)\sigma_1,\ \ (-x^*\pi_2)/\sigma_2,\ \ \rho^*)$$

.

Probability of fair, good or very good health (i.e., i =1, 2 and 3 respectively) and non-participation:

$$P_{i0} = \Phi_2((m_i - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2,\ \ \rho^*) - \Phi_2((m_{i-1} - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2,\ \ \rho^*)$$

.

Probability of fair, good or very good health and participation:

$$P_{i1} = \Phi((m_i - x^*\pi_1)/\sigma_1) - \Phi((m_{i-1} - x^*\pi_1)/\sigma_1) - \Phi_2((m_i - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2,\ \ \rho^*)$$

$$+ \Phi_2((m_{i-1} - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2,\ \ \rho^*)\ .$$

Probability of excellent health and non-participation:

$$P_{40} = \Phi((-x^*\pi_2)/\sigma_2) - \Phi_2((m_3 - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2, \rho^*)\ .$$

Probability of excellent health and participation:

$$P_{41} = 1 - \Phi((m_3 - x^*\pi_1)/\sigma_1) - \Phi((-x^*\pi_2)/\sigma_2) + \Phi_2((m_3 - x^*\pi_1)/\sigma_1,\ \ (-x^*\pi_2)/\sigma_2, \rho^*)$$

.

Where Φ is the univariate standard normal distribution function and Φ_2 the bivariate standard normal distribution function. σ_1^2, σ_2^2 and ρ^* are functions of θ_1, θ_2 and ρ.

Appendix 3: Two-stage estimation results[a]

A1: Two-stage estimation results				
	Males 15-49		Females 15-49	
	Coefficient	Standard error	Coefficient	Standard error
Labour force participation equation				
health	0.7467***	0.0821	0.3581***	0.0486
age/10	-0.0684	0.2836	-0.7227***	0.2040
age_2/100	-0.0242	0.0679	0.1600***	0.0507
degree	0.5142***	0.1833	0.5640***	0.0901
oth_psq	0.0567	0.1097	0.2085***	0.0715
yr12	0.2695	0.1873	0.0452	0.0932
married	-0.2765*	0.1664	-0.5500***	0.1579
sp_lf	0.4693***	0.1415	0.4545***	0.1467
em_lif	2.6089***	0.2495	2.1250***	0.1180
unem_lif	1.8403***	0.3119	1.1233***	0.2462
indig	0.1189	0.2850	0.0811	0.2151
cob_os	-0.1819	0.1523	-0.1365	0.1015
cob_n_en	0.1768	0.2223	0.0103	0.1275
chld04	-1.9401***	0.6855	-1.0110***	0.1484
chld514	-0.4292	0.2689	-0.3010***	0.1147
mar_04	2.2108***	0.7016	-0.2022	0.1650
mar_514	0.5793*	0.2986	0.4184***	0.1304
cons	-1.2563***	0.2845	-0.3066	0.1899
No of observations		3189		340
Log likelihood		-437.39		-1296.97
Health equation				
lf	-0.0244	0.1067	-0.0320	0.0329
age/10	-0.1241***	0.0391	-0.0603**	0.0242
degree	0.3116***	0.0985	0.2061***	0.0665
oth_psq	0.1265**	0.0561	0.1374***	0.0524
yr12	0.2035**	0.0864	0.1798***	0.0659
married	-0.0238	0.0568	0.0711	0.1003
sp_lf	0.1430*	0.0742	0.0758	0.0937
em_lif	0.4314	0.3268	0.3060***	0.1050
unem_lif	0.1303	0.2825	-0.0659	0.2060
indig	0.4791**	0.1950	-0.0611	0.1633
smok	-0.2050***	0.0407	-0.2862***	0.0377
no_act	-0.3190***	0.0519	-0.3997***	0.0426
drink	-0.1382**	0.0615	0.0529	0.0954
condi	-0.7247***	0.0976	-0.9029***	0.0659
pf_ind/100	1.3955***	0.1969	1.6955***	0.1529
trade	-0.0573	0.0559	-0.0324	0.1019
cle_s	-0.1245*	0.0645	-0.0288	0.0482
prd_tr	-0.0949	0.0757	-0.2816**	0.1224
labor	-0.0994	0.0750	-0.0582	0.0801
nev_w	0.1729	0.2259	0.0318	0.1792
cut_1	-1.4748***	0.2376	-1.2899***	0.1775
cut_2	-0.2680	0.2342	-0.1146	0.1785
cut_3	0.9813***	0.2357	1.1595***	0.1821
cut_4	2.2070***	0.2384	2.3928***	0.1863
No of observations		3189		3410
Log likelihood		-3837.06		-4041.05
*** significant at 1%, ** 5%, * 10%.				

a, standard errors are bootstrapped with 1000 replications.

A1: Two-stage estimation results (continued)				
	Males 50-64		Females 50-60	
	Coefficient	Standard error	Coefficient	Standard error
Labour force participation equation				
health	0.4105***	0.0582	0.4170***	0.0630
age/10	-0.9003***	0.1385	-0.8517***	0.1771
degree	0.5488***	0.2070	0.2373	0.1488
oth_psq	-0.0233	0.1168	-0.0091	0.1261
yr12	-0.1696	0.2069	0.2092	0.2378
married	-0.1682	0.1443	-0.9629***	0.1460
sp_lf	0.8675***	0.1255	1.0434***	0.1391
em_lif	7.4529***	1.0405	2.3017***	0.2141
unem_lif	6.7282***	1.3582	1.8743	1.3167
indig	-0.2501	0.6216	-0.1701	0.7064
cob_os	-0.0545	0.1363	-0.1707	0.1510
cob_n_en	0.1816	0.1762	-0.3114	0.1944
chld014	-0.2237	2.0544	-0.4268	0.8172
mar_014	0.3854	2.0789	0.3133	0.8743
cons	-6.8182***	1.0152	-1.4627***	0.2324
No of observations		1175		940
Log likelihood		-398.95		-394.84
Health equation				
lf	-0.4848	0.5120	0.3591*	0.1850
age/10	-0.2193	0.4260	0.3569**	0.1793
degree	0.8454**	0.4287	0.1422	0.1198
oth_psq	0.1111	0.0883	0.2162**	0.0955
yr12	0.0564	0.1591	0.0192	0.1808
married	-0.2201	0.1445	0.2339	0.2320
sp_lf	0.4585	0.4679	-0.1654	0.2379
em_lif	4.3639	3.9742	-0.6477	0.4617
unem_lif	2.5565	3.3829	-0.4127	1.3370
indig	-0.5932	0.5450	0.1662	0.5031
smok	-0.3395***	0.1300	-0.1553**	0.0795
no_act	-0.1955	0.1324	-0.3593***	0.0957
drink	0.2129	0.1473	-0.2308	0.5107
condi	-1.1381***	0.2158	-0.3886***	0.1343
pf_ind/100	2.9703***	0.7290	2.4838***	0.3626
trade	-0.1383	0.1037	-0.0460	0.2364
cle_s	0.1344	0.2022	0.1080	0.0935
prd_tr	-0.1631	0.1338	0.0433	0.2252
labor	-0.0974	0.1370	-0.1386	0.1608
nev_w			0.3112	0.2998
cut_1	3.1241	3.7683	-0.9522**	0.3993
cut_2	4.4135	3.7731	0.5018	0.4090
cut_3	5.8157	3.7760	1.9246***	0.4169
cut_4	7.1614*	3.7771	3.2680***	0.4280
No of observations		1175		940
Log likelihood		-1328.78		-1048.57
*** significant at 1%, ** 5%, * 10%.				