Health Status and Labour Force Participation: Evidence from Australia

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Abstract

This paper examines the effect of health on labour force participation using the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The potential endogeneity of health, especially self-assessed health, in the labour force participation equation is addressed by estimating the health equation and the labour force participation equation simultaneously. Taking into account the correlation between the error terms in the two equations, 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. However the effect is larger for the older groups and for women. 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. The null-hypothesis of exogeneity of health to labour force participation is rejected for all groups.

Key words: Self-reported health, labour force participation, endogeneity of health, simultaneous equation model

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1. Introduction

In this paper we examine the relationship between health status and labour force participation of working age men and women. One reason for being interested in this issue is that if poor health reduces labour productivity and leads to reduced labour force participation, 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 activities is necessary to estimate the costs of health limitations to the economy [1-3].

As a second concern, in the context of population ageing, understanding the relationship between health and labour market behaviour of older working age people has important policy implications. 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.

An issue in studying the relationship between health and labour force status is the measurement of health in general and the potential endogeneity of self-assessed health in particular. A more objective measure of health status is less likely to be subject to the rationalisation endogeneity problem associated with self-assessed measures of health. 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. An exception is Stern [4] using binomial indicators for health and labour force participation. We follow Stern in setting up the model, but we use the full information maximum likelihood (FIML) estimation method to estimate a simultaneous model using more than two levels of

health. For more than two levels of health, Stern used a two-stage estimation method which is less efficient.

The effect of health on labour market activities has been under extensive examination in the US and many research papers have been generated [2, 5]. 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. After an extensive review of the literature, Currie and Madrian [5] (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”. This paper seeks to extend the focus to a broader group. In addition, studies on this issue using Australian data are scarce. Exceptions are Wilkins [6] who looks at the impact of disability on labour supply (including employment probability and hours worked) and Brazenor [7] who examines the impact of disability on earnings. 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 objectively measured than the self-assessed health status used in most studies in the literature. 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.

This paper uses data from the recently released Household, Income and Labour Dynamics in Australia (HILDA) Survey. The advantage of these 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 [8] drew an analogy between “investment” in health and in other forms of human capital such as education. This approach was further developed by Grossman [9]. See Currie and Madrian [5] 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 [2]. 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

[2].

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 [10], 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 supply (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 [4, 11]. 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, although the direction of the impact is ambiguous.

In the US, health insurance is often tied to employment. As a result, labour force participation can be particularly important for persons with health problems, who do not qualify for a disability programme.¹ In Australia, similar to the situation in many European countries, all residents are covered by a public health insurance system (called Medicare). Coverage is independent of work status and the public system provides an adequate level of health care, therefore employment is not important for receiving the required level of health care. This universal coverage means that the health insurance status is unlikely to be an important factor in determining health. Additional insurance can be taken out for private health care, but this just shortens the waiting time for elective surgery and provides a choice in doctors or hospitals. This private insurance is on a voluntary basis and is not linked directly to employment.

The endogeneity just described arises from the assumption that health can be accurately

¹ We are grateful to an anonymous referee for pointing this out to us.

measured. However, in most of the survey data, only self-assessed health is available. Therefore, in the literature most studies that have included a health measure to explain work decisions have included individuals' self-assessed health as an explanatory variable [12]. However, with regard to the use of self-assessed health in estimating the effects of health on labour supply, several researchers raise the concern that self-assessed health may be used as a rationalisation for labour force status [4, 10, 12-15]. 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 and the effects tend to be overestimated. This endogeneity is different from that discussed in the previous paragraph. Here the endogeneity occurs due to the use of the self-assessed health measure, whereas in the previous paragraph 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. Self-assessed health may also suffer from measurement errors [15], but it is the rationalisation endogeneity that raises the major concern in the literature.

To account for the potential problems associated with self-assessed health variables, some authors have used more objectively measured health such as subsequent mortality [13, 14, 16] or specific health conditions to instrument self-assessed health [10, 15, 17, 18]. However, an objective measure of health, even if available in a dataset, is not free of problems [15]. The instrumental variable approach does not itself solve the problem of endogenous self-assessed health [12, 15].

2.2. *Modelling strategies*

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 [4] and are briefly described in this section. The model specification is 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 jointly normally distributed.

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 and only the total endogeneity can be estimated. However, when interpreting the θ_1 parameter it is useful to keep the distinction between the two types of endogeneity in mind.

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

$$(5) \ l^* = \theta_2 h^* + x_2 \beta_L + \varepsilon_L$$

$$\text{where } \theta_2 = \frac{\gamma_2}{(1 + \gamma_2 \alpha)}, \beta_L = \frac{\beta_2}{(1 + \gamma_2 \alpha)}, \text{ and } \varepsilon_L = \frac{(\varepsilon_2 - \gamma_2 \omega)}{(1 + \gamma_2 \alpha)}.$$

ε_h and ε_L are correlated through ω , even if ε_1 and ε_2 were assumed to be independent. However, 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 corresponding observed values of the endogenous variables are:

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

where (m_0, m_1, m_2, m_3) are unobserved cut-off points, and

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

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), and m_0, m_1, m_2, m_3 in equation (6). 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 [19].

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 (FIML) method [20]. Define

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

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

The log-likelihood function for the sample is

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

Appendix 1 provides the detailed probability definitions. Standard econometric packages do not provide this type of model. Therefore, a GAUSS programme was written to estimate the model.

Although the modelling approach here is similar to Stern's [4], 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. The two-stage method is essentially an instrumental variable method, where all exogenous variables are used as instruments to estimate each equation in the system separately (see for example, Greene [20]). 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.

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 (see econometric textbooks, such as Greene [20] or Judge *et al.* [21]). 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 not taken into account. Exogeneity can only be tested based on the significance of the labour force participation variable. This turns out to be important for our results.

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, which was conducted in the period between 24 August 2001 and 21 December 2001. Details of this survey are documented in Watson and Wooden [22].

The HILDA survey contains detailed information on individuals' labour market activity and history. 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. Specific examples of these long-term conditions were shown on a card, such as for example, limited use of fingers or arms, or problems with eye sight that could not be corrected with glasses or contact lenses. 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 [23]. 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 [24]. 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 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.

The model is estimated for four separate groups: men less than 50 years old, women less than 50 years old, men aged 50 or over and women aged 50 or over. These four groups are distinguished because we expect labour force participation to be quite different for each of the groups. In addition, the factors influencing the participation decision are likely to be different as well. 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 (male age-pension age is 65; female age-pension age is in a transition phase, but at the time of the interview was 61). 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.

Table 1 about here

A 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

49 report fair or poor health, while 20 percent aged 50 to 60 do so.

3.2. Model specification

Table 2 provides the definitions for all variables and shows in which equation they are included. The identification condition for simultaneous equation models is satisfied because a different set of independent variables is included in the two equations. That is, each equation contains some variables that do not appear in the other equation.

Table 2 about here

The variables included in the labour force participation equation are standard in the literature. However, for the health equation, some justification 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 [25]. Australian survey data show that the disability incidence rate increases with age [26]. It is also found that people aged 50 and over have a higher probability of entering the disability benefit program than people under 50 years of age [27]. It has long been noticed that health and marital status have a close relationship (see, for example, Beckett and Elliott [28], and references therein). 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 socioeconomic status (SES) on an individual's health since individual educational achievement is greatly influenced by the parents' SES. Finally, education with age and age squared are key factors in the determination of an individual's wage. Since earnings from wages are only observed for labour force participants and (potential) wage is likely to influence health, we include age, age squared and education as instruments for wage in the health and labour force equations. As mentioned above, the linear age term is also expected to affect health directly.

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, in addition to the more subjective and general question "In general would you say your health is excellent,

very good, good, fair, or poor?’. Unfortunately, such detailed objective 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 (*health condition*). This variable is included although it is self-reported, following a suggestion by Bound, Schoenbaum and Waidmann [29] that it is reasonable to treat self-reports of chronic health conditions as exogenous. Bound, Schoenbaum and Waidmann [30] argue that survey questions that are more specific and concrete should be less subjective and therefore less susceptible to the rationalisation endogeneity problems. The variable, *health condition*, is used here in a similar way to Stern [4]. The difference is that Stern includes a list of specific long-term health conditions in his health equation, while we only have a summary indicator. However, HILDA respondents are shown a card listing specific examples of these conditions when answering this question. The second indicator is one of the SF-36 indices, the index for physical functioning. Because this index is constructed based on individuals’ answers to the questions about specific physical functioning limitations, such as for example, climbing one flight of stairs, lifting or carrying groceries, or bending, kneeling or stooping, the index can be treated as an exogenous variable. By including the above variables (which are assumed to be exogenous to labour force participation) in the health equation we are taking out 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, because long-term health conditions are now taken into account, when comparing those in the labour force with those out of the labour force. There is no need to include these long-term conditions in the labour force participation equation separately as they are already captured by the health status variable.

By including the smoking, heavy drinking and the lack of physical activities variables in the health equation only, we assume that they affect labour force participation only through their impacts on health. Smoking has been used as a rate of time preference indicator [31], but for our data there is no strong indication that smoking or drinking would affect labour force participation except indirectly through health. Appendix 2 shows that labour force participants are slightly less likely to be a smoker or heavy drinker, although the difference is nearly non-existent for some groups. The relationship of smoking and heavy drinking with health is much stronger.

The impact of unemployment on health has been discussed frequently [32, 33] and is included here as well. The inclusion of the employment history variable 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. The variable, *never worked*, is included to indicate those who have never worked and have therefore no an occupation. Although occupation may be thought to affect the probability of unemployment, it is unlikely to affect labour force participation, except through the job quality component. In addition, those who have never worked are all out of the labour force and could not be included in the model if this group of variables were included in the labour force participation equation. Therefore, the occupation variables are only included in the health equation, but age, age squared and education are already included as instruments for wage and it is assumed that these variables also control for the job quality aspect of occupation. If this assumption is wrong and the error term of the labour force participation equation still contains unobserved (potential) job quality, then the effect of health on labour force participation is expected to be overestimated due to the correlation between health and unobserved job quality.

There are a few variables in the labour force participation equation which are not included in the health equation. These are being an immigrant and the presence of children. Firstly, being an immigrant, especially from a non-English speaking background, may affect labour force participation through language or cultural problems but it is unlikely to affect health if subgroups of countries of origin, with for example poor health care or different propensities for diseases, cannot be distinguished. For aggregate groups of immigrants, the overall effect may be small, given that the effect for individuals from different countries may offset each other. In addition, as the duration since the immigrant's arrival in Australia increases, their health status will

become more similar to the health status of individuals born in Australia. Similarly having children interacted with married/de facto status is likely to affect labour force participation, particularly of women, but it is not likely to affect an individual's health status in a specific direction.

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.

Table 3 about here

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 individuals, 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 drinking is more likely among younger men than any other group.

4. Empirical results

4.1. FIML results for a simultaneous model of labour force participation and health

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 [34]. As a result, the choice of the starting values for the parameters becomes important. Following suggestions by Maddala [19] and Greene [34], 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. From Table 4, it can be seen that in general the significant exogenous variables have the expected sign. Cai and Kalb [35] provide a more extensive discussion of the results including the effects of the exogenous variables. In this paper, we focus our discussion on the estimates for the endogenous variables health and labour force participation.

Table 4 about here

Examining the labour force participation equation (equation 5) first, 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 (independent of whether this is due to rationalisation endogeneity or true endogeneity), 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 being in one of 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.

Table 5 about here

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.

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.

Turning to the second equation in the model (equation 4), we find that the feedback effect of labour force participation on health, represented by θ_1 , 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. For older females the estimated effect of labour force participation on health is positive and significant. In the following we interpret these feedback effects in the light of the two types of endogeneity identified in Section 2.2: true endogeneity and rationalisation endogeneity. 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 of θ_1 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 [4]. 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 for 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 [36] 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.

The above results are similar to what is found in the literature, as discussed by Cai and Kalb [35]. 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. 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.

The estimated correlation between the two equations, ρ , is negative significant for women and insignificant for men. This indicates that for women there may exist unobserved characteristics, which increase labour force participation but decrease health status. For example, ambition may increase the probability of participation, while at the same time making these women more vulnerable to stress-related health problems by trying to combine the demands of a successful high-level career with family responsibilities. The latter is often less important for men.

For older men and women, the direct effect from labour force participation and the correlation work in opposite directions (although insignificantly for men) similar to the effects in Stern [4]. This means the direction of the bias on the health coefficient in the participation equation caused by endogeneity is undetermined. However, the coefficients on health are smaller in the two-stage method and in the FIML where ρ is restricted to zero than in the unrestricted FIML, which indicates a downward bias to zero. For younger men and women, the two effects work in the same direction, causing a bias towards zero of the health coefficient.

4.2. Test for exogeneity of health in the labour force participation equation

The model in the previous section allows for a feedback effect of labour force participation on health. This takes into account the potential endogeneity of health in the labour force participation equation. If health were not endogenous, a simpler single-

equation model could have been estimated for labour force participation, including health as an exogenous variable. Therefore, in this subsection, we test for the endogeneity of health to check whether the more complex approach is needed.

If self-assessed health were 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) would be zero. Hence, the null hypothesis for exogeneity is

$$H_0 : \theta_1 = 0, \text{ and } \rho = 0;$$

$$H_A : \theta_1 \neq 0, \text{ or } \rho \neq 0.$$

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 means that health is rightly treated as an endogenous variable in the labour force participation equation. This result is quite different from the two-stage estimation, where, based on the significance of the coefficient on the labour force participation variable in the health equation, the exogeneity hypothesis is rejected for older females only.

Table 6 about here

4.3. Comparing estimates using FIML and the two-stage method

To compare the results from the two-stage method with the FIML method, we also carried out the two-stage estimation. Table 7 summarises the estimated effects for the main variables of interest using the two approaches. The full two-stage results are not reported in this paper, but can be found in Cai and Kalb [35].

Table 7 about here

A surprising difference between the results from the two estimation methods 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 could be due to the lower efficiency of the estimation method. The lower efficiency could be most apparent for young males because of the lack of variation in the predicted value for the labour force participation variable in this group. 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 small (the variation coefficient, which equals the standard deviation divided by the mean value, of the predicted value for the labour force participation variable is much smaller for younger males than for the other three groups). This 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, where efficiency of the estimation method is likely to be more important.

4.4. Comparison to other studies

In the literature, the estimated effects of health on labour force participation are quite different across studies. This is mainly because authors use different measures of health. A summary on the measures used in different studies on the effects of health on labour participation in the US is provided in Currie and Madrian [5] (p. 3334). 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 [4] 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 [4]. However, in terms of the health endogeneity issue,

we have a similar finding to Stern. The direction of the bias from endogeneity is opposite to the hypothesis in the literature, especially for the case of younger males. That is, there is a negative feedback effect of labour force participation on health.

It is also worth noting that Stern [4] only found 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.

The relationship between health and labour force participation appears to be different in different age-gender groups. Stern [4] did 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 [4] 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 the Australian 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. Therefore, poor health is likely to reduce productivity and although health also affects younger individuals, this effect is more important for older people and for women. This is clearly

shown by Table 5 in this paper, where the probability of labour force participation is predicted conditional on having a specific level of health. The estimation of one model using pooled data would have disguised this diversity.

However, the rationalisation endogeneity of health status 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 younger males and older females. In the case of younger males, the sign of the labour force participation variable is opposite to the rationalisation hypothesis in the literature, which is a similar finding to Stern's [4]. 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 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 predicted values for the endogenous variables. The insignificance of the labour force participation variable in the two-stage method could be due to the lower efficiency of this estimation method. The lower efficiency in the two-stage method is exacerbated by the lack of variation in the predicted value for the labour force participation variable for young males. In addition to being more efficient than the two-stage method, FIML allows a joint test of the exogeneity hypothesis. For these reasons, the FIML method and the two-stage approach may lead to different conclusions in some circumstances, such as in this case. For example, using the two-stage approach the null hypothesis of exogeneity could not be rejected for younger women and men, whereas it was rejected when using FIML.

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Appendix 1: 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:

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

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

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

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

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 2: Smoking and heavy drinking cross tabulations

Labour force participation:	Non-smoker	Smoker	Non-heavy drinker	Heavy drinker	No. obs
Males 15-49					
Non-participant	32.26	67.74	79.57	20.43	186
participant	44.96	55.04	85.38	14.62	3,003
Males 50-64					
Non-participant	27.57	72.43	92.96	7.04	341
participant	41.08	58.92	95.57	4.43	835
Females 15-49					
Non-participant	45.41	54.59	94.82	5.18	850
participant	50.9	49.1	95.16	4.84	2,560
Females 50-60					
Non-participant	53.63	46.37	99.16	0.84	358
participant	57.04	42.96	98.97	1.03	582
Health status:					
Males 15-49					
Poor	25	75	85.42	14.58	48
Fair	32.3	67.7	82.47	17.53	291
Good	38.84	61.16	83.58	16.42	1,017
Very good	46.88	53.12	85.85	14.15	1,265
Excellent	55.63	44.37	87.15	12.85	568
Males 50-64					
Poor	15	85	98.75	1.25	80
Fair	29.38	70.62	92.27	7.73	194
Good	34.43	65.57	93.67	6.33	395
Very good	45.09	54.91	96.29	3.71	377
Excellent	47.69	52.31	95.38	4.62	130
Females 15-49					
Poor	25.37	74.63	94.03	5.97	67
Fair	38.16	61.84	93.42	6.58	304
Good	42.79	57.21	94.48	5.52	1,033
Very good	52.79	47.21	95.54	4.46	1,345
Excellent	61.12	38.88	95.92	4.08	661
Females 50-60					
Poor	44.74	55.26	97.37	2.63	38
Fair	48.15	51.85	97.78	2.22	135
Good	54.09	45.91	99.37	0.63	318
Very good	58.05	41.95	99.39	0.61	329
Excellent	65.83	34.17	99.17	0.83	120

Appendix for referees' information: Two-stage estimation results

	Males 15-49		Females 15-49	
	Coefficient	Standard error ^(a)	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 squared/100	-0.0242	0.0679	0.1600***	0.0507
degree	0.5142***	0.1833	0.5640***	0.0901
other post-sch qual	0.0567	0.1097	0.2085***	0.0715
completed year 12	0.2695	0.1873	0.0452	0.0932
married	-0.2765*	0.1664	-0.5500***	0.1579
spouse in labour force	0.4693***	0.1415	0.4545***	0.1467
employment history	2.6089***	0.2495	2.1250***	0.1180
unemployment history	1.8403***	0.3119	1.1233***	0.2462
indigenous	0.1189	0.2850	0.0811	0.2151
born overseas	-0.1819	0.1523	-0.1365	0.1015
born non-En country	0.1768	0.2223	0.0103	0.1275
child 0-4	-1.9401***	0.6855	-1.0110***	0.1484
child 5-14	-0.4292	0.2689	-0.3010***	0.1147
married*child 0-4	2.2108***	0.7016	-0.2022	0.1650
married*child 5-14	0.5793*	0.2986	0.4184***	0.1304
constant	-1.2563***	0.2845	-0.3066	0.1899
Number of observations		3189		340
Log likelihood		-437.39		-1296.97
Health equation				
Labour force	-0.0301	0.1054	0.0113	0.0368
age/10	-0.0966	0.1148	0.2419*	0.1242
age squared/100	-0.0074	0.0282	-0.0775**	0.0305
degree	0.3142***	0.0944	0.1807***	0.0652
other post-sch qual	0.1267**	0.0559	0.1250**	0.0530
completed year 12	0.2072**	0.0862	0.1824***	0.0668
married	-0.0270	0.0601	0.0840	0.1039
spouse in labour force	0.1466**	0.0738	0.0515	0.0977
employment history	0.4454	0.3198	0.2150*	0.1178
unemployment history	0.1404	0.2787	-0.0759	0.2130
indigenous	0.4828**	0.1983	-0.0652	0.1586
smoker	-0.2057***	0.0422	-0.2911***	0.0387
lack physical activity	-0.3188***	0.0508	-0.4017***	0.0426
heavy drinker	-0.1379**	0.0631	0.0665	0.0970
health condition	-0.7299***	0.0998	-0.8829***	0.0680
physical functioning/100	1.4002***	0.1919	1.6664***	0.1520
tradesperson	-0.0572	0.0575	-0.0075	0.1031
clerical-service	-0.1235*	0.0661	-0.0114	0.0468
production-transport	-0.0970	0.0804	-0.2695**	0.1137
labourer	-0.0998*	0.0758	-0.0386	0.0836
never worked	0.1754	0.2223	0.0997	0.1776
cut-off point m_0	-1.4507***	0.2470	-1.1076***	0.1972
cut-off point m_1	-0.2439	0.2436	0.0671	0.2002
cut-off point m_2	1.0053***	0.2458	1.3427***	0.2018
cut-off point m_3	2.2311***	0.2495	2.5777***	0.2059
No of observations		3189		3410
Log likelihood		-3837.02		-4037.70

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
other post-sch qual	-0.0233	0.1168	-0.0091	0.1261
completed year 12	-0.1696	0.2069	0.2092	0.2378
married	-0.1682	0.1443	-0.9629***	0.1460
spouse in labour force	0.8675***	0.1255	1.0434***	0.1391
employment history	7.4529***	1.0405	2.3017***	0.2141
unemployment history	6.7282***	1.3582	1.8743	1.3167
indigenous	-0.2501	0.6216	-0.1701	0.7064
born overseas	-0.0545	0.1363	-0.1707	0.1510
born non-En country	0.1816	0.1762	-0.3114	0.1944
child 0-14	-0.2237	2.0544	-0.4268	0.8172
married*child 0-14	0.3854	2.0789	0.3133	0.8743
constant	-6.8182***	1.0152	-1.4627***	0.2324
Number of observations		1175		940
Log likelihood		-398.95		-394.84
Health equation				
Labour force	-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
other post-sch qual	0.1111	0.0883	0.2162**	0.0955
completed year 12	0.0564	0.1591	0.0192	0.1808
married	-0.2201	0.1445	0.2339	0.2320
spouse in labour force	0.4585	0.4679	-0.1654	0.2379
employment history	4.3639	3.9742	-0.6477	0.4617
unemployment history	2.5565	3.3829	-0.4127	1.3370
indigenous	-0.5932	0.5450	0.1662	0.5031
smoker	-0.3395***	0.1300	-0.1553**	0.0795
lack physical activity	-0.1955	0.1324	-0.3593***	0.0957
heavy drinker	0.2129	0.1473	-0.2308	0.5107
health condition	-1.1381***	0.2158	-0.3886***	0.1343
physical functioning/100	2.9703***	0.7290	2.4838***	0.3626
tradesperson	-0.1383	0.1037	-0.0460	0.2364
clerical-service	0.1344	0.2022	0.1080	0.0935
production-transport	-0.1631	0.1338	0.0433	0.2252
labourer	-0.0974	0.1370	-0.1386	0.1608
never worked			0.3112	0.2998
cut-off point m_0	3.1241	3.7683	-0.9522**	0.3993
cut-off point m_1	4.4135	3.7731	0.5018	0.4090
cut-off point m_2	5.8157	3.7760	1.9246***	0.4169
cut-off point m_3	7.1614*	3.7771	3.2680***	0.4280
No of observations		1175		940
Log likelihood		-1328.78		-1048.57

Note: a) Because predicted values were used in the second stage estimation, the standard method of calculating standard errors is no longer appropriate. In the table, the standard errors were bootstrapped with 1000 replications.

Tables

Table 1: Labour force status^a by self-assessed health status

	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

Note a: In labour force includes employed and unemployed persons.

Table 2: Variable definitions**Endogenous variables:**

labour force	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 (a)
age squared	age deviation squared (a); only included for the younger age groups
married	1 if married or de facto
indigenous	1 if indigenous or Torres Strait Islander

Education

degree	1 if has a bachelor or higher degree
other post-sch qual	1 if has other non-degree post-school qualifications
completed year 12	1 if completed year 12

Job history and spouse's labour force status

spouse in labour force	1 if married and the spouse in LF
employment history	proportion of time (since leaving school) in employment
unemployment history	proportion of time (since leaving school) in unemployment

Additional variables appearing in the labour force participation equation:*Demographic*

born overseas	1 if born overseas
born non-En country	1 if born in non-English speaking foreign country
child 0-4	1 if has child(ren) under 4 years of age
child 5-14	1 if has child(ren) aged 5 to 14
child 0-14	1 if has child(ren) aged 0 to 14 (b)
married*child 0-4	interaction between married and child 0-4
married*child 5-14	interaction between married and child 5-14
married*child 0-14	interaction between married and child 0-14 (b)

Additional variables appearing in the health equation:*Occupation*

tradesperson	1 if last or current job as a tradesperson or related worker
clerical-service	1 if last or current job as a clerical, sales or service worker
production-transport	1 if last or current job as a production or transport worker
labourer	1 if last or current job as a labourer or related worker
other occupations	1 if last or current job in an occupations other than those listed above
never worked	1 if never worked (c)

Health related

smoker	1 if currently smoking or ever smoked
health condition	1 if has long-term health conditions
lack physical activity	1 if lack of physical activity, defined as no physical activity at all or less than once per week
heavy drinker	1 if a heavy drinker, defined as drinking more than 6 standard drinks a day when drinking
physical functioning	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 *child 0-14* and *married*child 0-14* are used for older people in place of *child 0-4*, *child 5-14*, *married*child 0-4*, and *married*child 5-14* 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.

c: The variable, never worked, 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.

Table 3: Descriptive statistics of the sample

Variable	Males 15-49		Females 15-49		Males 50-64		Females 50-60	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Endogenous variables								
<i>labour force</i>	0.94	0.23	0.75	0.43	0.71	0.45	0.62	0.49
<i>health</i>	2.63	0.93	2.65	0.95	2.24	1.07	2.38	1.01
Demographic								
<i>age</i>	35.02	8.73	34.91	8.47	56.43	4.24	54.57	3.11
<i>married</i>	0.65	0.48	0.68	0.47	0.81	0.39	0.74	0.44
<i>child 0-4</i>	0.22	0.41	0.25	0.43	0.02	0.13	0.00	0.03
<i>child 5-14</i>	0.30	0.46	0.39	0.49	0.09	0.29	0.05	0.22
<i>child 0-14</i>	0.43	0.50	0.53	0.50	0.10	0.30	0.05	0.22
<i>married*child 0-4</i>	0.21	0.41	0.21	0.41	0.02	0.13	0.00	0.03
<i>married*child 5-14</i>	0.29	0.45	0.32	0.47	0.08	0.28	0.04	0.19
<i>married*child 0-14</i>	0.42	0.49	0.44	0.50	0.09	0.29	0.04	0.19
<i>born overseas</i>	0.21	0.41	0.21	0.41	0.33	0.47	0.29	0.45
<i>born non-En country</i>	0.11	0.31	0.12	0.33	0.17	0.37	0.15	0.36
<i>indigenous</i>	0.02	0.12	0.02	0.16	0.01	0.09	0.01	0.10
Education								
<i>degree</i>	0.21	0.41	0.26	0.44	0.19	0.39	0.20	0.40
<i>other post-sch qual</i>	0.46	0.50	0.34	0.47	0.43	0.50	0.30	0.46
<i>year 12</i>	0.12	0.32	0.14	0.35	0.08	0.27	0.06	0.24
<i>lower than year 12</i>	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								
<i>tradesperson</i>	0.22	0.41	0.04	0.20	0.13	0.34	0.02	0.15
<i>clerical-service</i>	0.14	0.34	0.44	0.50	0.14	0.35	0.40	0.49
<i>production-transport</i>	0.13	0.33	0.03	0.17	0.14	0.35	0.05	0.22
<i>labourer</i>	0.11	0.32	0.09	0.28	0.10	0.30	0.13	0.34
<i>other occupation</i>	0.41	0.49	0.41	0.49	0.48	0.50	0.39	0.49
<i>spouse in labour force</i>	0.47	0.50	0.64	0.48	0.51	0.50	0.51	0.50
<i>employment history</i>	0.87	0.21	0.71	0.29	0.93	0.12	0.66	0.28
<i>unemployment history</i>	0.05	0.13	0.04	0.12	0.02	0.05	0.01	0.04
<i>never worked</i>	0.01	0.11	0.02	0.16			0.01	0.11
Health related								
<i>smoker</i>	0.56	0.50	0.50	0.50	0.63	0.48	0.44	0.50
<i>health condition</i>	0.17	0.38	0.14	0.35	0.35	0.48	0.28	0.45
<i>lack physical activity</i>	0.23	0.42	0.29	0.45	0.28	0.45	0.28	0.45
<i>heavy drinker</i>	0.15	0.36	0.05	0.22	0.05	0.22	0.01	0.10
<i>physical functioning</i>	89.76	18.46	88.11	18.38	78.34	24.29	77.94	23.27
<i>No of observations</i>	3189		3410		1175		940	

Table 4: Full information maximum likelihood results

	Males 15-49		Females 15-49	
	Coefficient	Standard error	Coefficient	Standard error
Labour force participation – equation (5)				
health	0.8198***	0.1201	0.3501***	0.0398
age/10	-0.0152	0.2017	-0.6938***	0.184
age squared/100	-0.027	0.0512	0.1539***	0.0458
degree	0.4383***	0.1531	0.5291***	0.0855
other post-sch qual	0.0644	0.1009	0.1959***	0.071
completed year 12	0.2496	0.1661	0.0353	0.0949
married	-0.103	0.1245	-0.5529***	0.1421
spouse in labour force	0.3522***	0.1249	0.4322***	0.1171
employment history	2.0623***	0.2188	2.0218***	0.1216
unemployment history	1.4939***	0.3166	1.0569***	0.2421
indigenous	0.0056	0.4559	0.0861	0.1407
born overseas	-0.2576**	0.1019	-0.0795	0.0906
born non-En country	-0.0105	0.1208	-0.029	0.1116
child 0-4	-1.3799***	0.496	-0.9852***	0.1274
child 5-14	-0.1749	0.2059	-0.3252***	0.1181
married*child 0-4	1.5100***	0.5029	-0.1614	0.1424
married*child 5-14	0.2018	0.2188	0.4541***	0.1297
constant	-1.5763***	0.3756	-0.2746	0.1815
Health – equation (4)				
Labour force	-0.7186***	0.1657	0.0113	0.0415
age/10	-0.1288	0.1619	0.2321**	0.1137
age squared/100	-0.0314	0.0412	-0.0755***	0.029
degree	0.6423***	0.1307	0.1568**	0.0682
other post-sch qual	0.1924**	0.081	0.1170**	0.0528
completed year 12	0.4112***	0.1331	0.1765***	0.0632
married	-0.0373	0.0915	0.0846	0.1072
spouse in labour force	0.3928***	0.1077	0.0504	0.1024
employment history	1.9391***	0.3678	0.1933	0.1229
unemployment history	1.1792***	0.3349	-0.0636	0.1633
indigenous	0.6010*	0.3487	-0.0632	0.099
smoker	-0.2475***	0.0484	-0.2819***	0.0384
lack physical activity	-0.3514***	0.055	-0.3781***	0.0415
heavy drinker	-0.1741***	0.0676	0.0915	0.0825
health condition	-0.8998***	0.0698	-0.9029***	0.0549
physical functioning/100	1.7006***	0.1211	1.6605***	0.0913
tradesperson	-0.082	0.0694	-0.0622	0.1021
clerical-service	-0.1343*	0.0738	-0.0433	0.0495
production-transport	-0.1563*	0.0801	-0.2848***	0.1087
labourer	-0.1380*	0.0828	-0.1067	0.0766
never worked	0.0874	0.1955	-0.022	0.1185
cut-off point m_0	-0.4195	0.37	-1.1700***	0.1701
cut-off point m_1	0.5200*	0.2743	0.0108	0.1564
cut-off point m_2	1.4877***	0.213	1.2878***	0.1562
cut-off point m_3	2.4357***	0.2222	2.5215***	0.1562
correlation ρ	0.0086	0.1768	-0.3117***	0.0643
No of observations		3189		3410
Log likelihood		-4268.57		-5332.11

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

Table 4: Full information maximum likelihood results (continued)

	Males 50-64		Females 50-60	
	Coefficient	Standard error	Coefficient	Standard error
Labour force participation – equation (5)				
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
other post-sch qual	-0.0189	0.1225	-0.0258	0.1293
completed year 12	-0.1690	0.2301	0.1789	0.2035
married	-0.1630	0.1439	-0.9453***	0.1476
spouse in labour force	0.8570***	0.1224	1.0039***	0.1377
employment history	7.3069***	0.518	2.2171***	0.2184
unemployment history	6.5844***	1.0703	1.7650*	1.0389
indigenous	-0.2832	0.4960	-0.0933	0.4883
born overseas	-0.0259	0.1176	-0.0178	0.1195
born non-En country	0.1631	0.1624	-0.4269**	0.1718
child 0-14	-0.3920	0.3834	-0.3894	0.3176
married*child 0-14	0.5025	0.4343	0.3772	0.3834
constant	-8.8459***	2.7508	-1.1854***	0.2162
Health – equation (4)				
Labour force	-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
other post-sch qual	0.0672	0.1049	0.1982**	0.1000
completed year 12	0.0207	0.1877	0.0038	0.1623
married	-0.1929*	0.1116	0.2556	0.2447
spouse in labour force	0.5189	0.3913	-0.2024	0.2655
employment history	4.7888	3.2053	-0.7216	0.4776
unemployment history	3.2628	3.3715	-0.2480	0.8314
indigenous	-0.5293	0.3271	0.1082	0.3700
smoker	-0.2345***	0.0858	-0.1699***	0.0652
lack physical activity	-0.2469***	0.0899	-0.1841**	0.0788
heavy drinker	0.2171	0.1562	0.1144	0.3323
health condition	-0.9262***	0.2023	-0.4965***	0.1138
physical functioning/100	2.2823***	0.4886	2.3408***	0.4222
tradesperson	-0.1174	0.1061	-0.0489	0.2317
clerical-service	0.0061	0.0972	0.0358	0.0771
production-transport	-0.2054	0.1094	-0.0813	0.1384
labourer	-0.1318	0.1170	-0.2031*	0.1110
never worked			0.1922	0.4016
cut-off point m_0	3.5723	3.1861	-1.1001***	0.3437
cut-off point m_1	4.5241*	2.7077	0.3307	0.3981
cut-off point m_2	5.5534**	2.1924	1.7299***	0.4657
cut-off point m_3	6.5312***	1.7070	3.0410***	0.5237
correlation 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%.

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	0.9279	-0.7117	-2.4318
Fair	0.9345	-0.6254	-1.7325
Good	0.9404	-0.5676	-1.1140
Very good	0.9458	-0.5496	-0.5496
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	0.7194	-1.7619	-6.5343
Fair	0.7323	-1.6937	-4.8579
Good	0.7449	-1.5957	-3.2187
Very good	0.7570	-1.6493	-1.6493
Excellent	0.7697		
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		

Table 6: Test for exogeneity

	Males 15-49	Females 15-49	Males 50-64	Females 50-60
$\chi^2(2)$	59.91	35.45	12.92	30.94

Note: all statistics are significant at the 5 percent level.

Table 7: Comparison of coefficients on the endogenous variables

	FIML estimation		Two-stage estimation	
	Coefficient	Standard error	Coefficient	Standard error
Males 15-49				
Health	0.8198***	0.1201	0.7467***	0.0821
Labour force	-0.7186***	0.1657	-0.0301	0.1054
Female 15-49				
Health	0.3501***	0.0398	0.3581***	0.0486
Labour force	0.0113	0.0415	0.0113	0.0368
Males 50-64				
Health	0.5530**	0.2800	0.4105***	0.0582
Labour force	-0.5802	0.4553	-0.4848	0.5120
Female 50-60				
Health	0.4276***	0.0649	0.4170***	0.0630
Labour force	0.3936**	0.1952	0.3591*	0.1850

Note: Coefficients are not comparable across groups (see Section 2.2).