# The Effects of Health and Health Shocks on Hours Worked*

Lixin Cai[1], Kostas Mavromaras[1,2] and Umut Oguzoglu[1,2]

[1] Melbourne Institute of Applied Economic and Social Research
University of Melbourne
[2] IZA

May 2008

Abstract: We investigate the impact of health on working hours in recognition of the fact that leaving the labour market due to persistently low levels of health stock or due to new health shocks, is only one of the possibilities open to employees. We use the first six waves of the HILDA survey to estimate the joint effect of health status and health shocks on working hours using a dynamic random effects Tobit model of working hours to account for zero working hours. We follow Heckman (1981) and approximate the unknown initial conditions with a static equation that utilizes information from the first wave of the data. Predicted individual health stocks are used to ameliorate the possible effects of measurement error and endogeneity. We conclude that overall lower health status results in lower working hours and that health shocks lead to further reductions in working hours when they occur. Estimation results show that the model performs well in separating the time-persistent effect of health stock (health status) and the potentially more transient health shocks on working hours.

JEL classification: J220, I100, C330
Keywords: working hours, health, health shocks, Tobit estimation

**Acknowledgements:** This paper uses the confidentialised unit record file of the Household, Income and Labour Dynamics in Australia (HILDA) survey. The HILDA Survey project was initiated and is funded by the Australian Department of Families, Housing, Community Services and Indigenous Affairs (FaCHSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research. The findings and views reported in this paper, however, are those of the authors and should not be attributed to either FaCHSIA or the Melbourne Institute. Financial support from the Australian Research Council (Discovery Project Grant #DP0663362) and the Faculty of Economics and Commerce of the University of Melbourne is gratefully acknowledged. First authorship is shared equally between all authors. The usual disclaimed applies.

# 1. Introduction

Understanding the empirical relationship between health and labour market outcomes is necessary for a number of reasons. The design and evaluation of the cost effectiveness of policy interventions relating to the prevention and cure of disease need concrete evidence which is based on understanding how health relates to labour market behaviour (Currie and Madrian 1999). Demographic changes, in particular ageing of the labour force in most western countries make health issues in the labour market more prominent in many ways. On the one hand the labour force is getting older, on the other hand older people are getting healthier, richer and more indispensable in an environment which is switching from skilled labour demand deficits (the post WW-II environment) to shortages of skilled labour (the emerging $21^{st}$ century environment). Looked at from a historic perspective, the start of the $21^{st}$ century will be one of rapid change in some of the key parameters surrounding labour market behaviour. Population health changes and the way these play out in terms of labour market outcomes will be one of the major such key parameters.

There has been work on the effects that health has on labour market participation, which concentrates on two main questions. First, what is the impact of health and health shocks on the labour market participation of prime age individuals (Curie and Madrian 1999, Cai and Kalb 2006, Gannon 2004, Cai 2007, Oguzoglu 2007). Second, what is the impact of health and health shocks on the labour market participation of specific groups where health may play a special role in their outcomes. These have included the old (where health problems may be expected and where existing preparations for retirement may make a permanent exit more likely) and the disabled (where a continued but lesser involvement in the labour market may be feasible and desirable and where re-training may remove a proportion of the effect of a health shock: see Haardt 2007, Rice et al. 2007, Zucchelli et al. 2007)

The distinction between health status and health shocks is prominent in this context. Health status can be thought of as a measure of the long term equilibrium relationship between health and labour market status. Simply put, healthier people are more productive in the long run. Health shocks, by contrast are a short term measure of the change in productivity that results from a rapid and typically unexpected health status deterioration. Simply put, when people get ill in a serious way, then their productivity is reduced and they have to adapt their labour market involvement to suit their new capabilities.

This paper offers two distinct improvements to the existing literature. First, it uses a data set that reports separate measures of health status and health shocks. This way the probability that measurement errors in the health status variable may contaminate the health shock variable is reduced, as the health shock measure is derived from independent questions designed for this specific purpose. Second, this paper does not treat labour market involvement as an either-or outcome: that is, it does not assume that, for example, after a health shock one will either stay in the same job or stop working altogether. The paper allows for the crucial possibility that people who experience health shocks may not choose to leave employment altogether, but may instead choose to stay in employment with reduced working hours.

An additional motivation of this paper is that it refers to a labour market that can be usefully contrasted with a number of western labour markets, in particular western continental European markets. Australia has a labour market which imposes fewer restrictions on dismissals and has a relatively decentralised bargaining structure which allows individual firms to strike agreement with their workers that are tailored to specific worker-firm matches. Further, the Australian labour market offers a wider variety of possibilities in terms of permissible types of employment contracts with a great variability in the hours worked by the labour force. One of the results is that Australia has one of the highest rates of part time employment in the OECD, which, combined with a relatively high incidence of long hours employment leaves a much smaller share of the labour force working the standard 35 to 40 hours per week (see Drago and Wooden 2007). As such one would expect that the adjustments in hours that we observe in Australia following the occurrence of a health shock will be more likely to represent a choice that is less constrained by regulations and that reflects more the post-health shock productivity and bargaining positions of the worker and the firm. Given all the other fundamental similarities between western European labour markets and the Australian labour market, one could therefore think of the Australian evidence usefully, but in a very broad brush way, as a counterfactual for a continental European labour market that has relaxed a good number of its workplace regulations.

The paper estimates a panel data Tobit model which allows the presence in the data of both responses to a health shock (namely, of leaving work or reducing working hours) and is flexible enough to control for some bunching of the working hours responses around the zero hours mark. We follow the literature by using a predicted health status variable (in the place of reported health) in order to ameliorate possible measurement error and endogeneity problems (Disney, Emmerson and Wakefield 2006).

Labour supply behaviour has been found to be highly persistent (Hyslop 1999) and working hours are not an exception. A drop in current working hours may be due to a reduction in the past working hours rather than a direct response to a current health shock. This problem may especially be prevalent for older persons whose working hours are on a gradual retirement path. If this sort of persistent behaviour is ignored, the impact of health shocks on working hours may be exaggerated. We address this issue by employing a dynamic panel data model where lagged working hours and unobserved individual specific factors are controlled for. We use the method proposed by Heckman (1981) to control for initial conditions.

The main conclusions of the paper are that health stock and health shocks have a statistically significant effect on working hours in the manner predicted by theory, that the estimation results on the dynamic properties of the model are as expected and that there are some gender differences in the estimation results which accord with theory but lack in statistical significance. The remainder of the paper is structured as follows. Section 2 describes the data used and discusses some of the caveats relating to the use of self reported health measures. Section 3 presents the econometric model. Section 4 presents and discusses the estimation results. Section 5 concludes. An Appendix contains detailed estimation results and descriptive statistics.

## 2. The Data

The data used for this paper come from the first six waves of the Household, Income and Labour Dynamics in Australia (HILDA) Survey. Details of this survey are documented in Watson and Wooden (2004). In the first wave, 7,683 households representing 66 percent of all in-scope households were interviewed, generating a sample of 15,127 persons who were at least 15 years old and eligible for interviews, of whom 13,969 were successfully interviewed. Subsequent interviews for later waves were conducted one year apart. 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 upon completion by mail or handed back to the interviewer at a subsequent visit to the household.

The HILDA survey contains detailed information on each individual's 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, individuals were asked whether they had a long-term condition, impairment or disability that 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, examples of which are limited use of fingers or arms, or problems with eyesight that could not be corrected with glasses or contact lenses. In the self-completion questionnaire, the Short Form 36 (SF-36) health status questions were asked. The SF-36 is a measure of general health and wellbeing, and produces scores for eight dimensions of health (Ware *et al.,* 2000).

The first question in the SF-36 is the standard self-reported health status question, asking: "*In general, would you say your health is excellent, very good, good, fair or poor?*". This measure is used as the dependent variable in the health determination model for predicting health stock. We employ two measures for *health shocks*. The first measure of a health shock is the occurrence of a serious injury or illness within the past year. For this measure a binary variable is generated which takes the value of 1 where a serious injury or illness occurred and zero otherwise. The second measure of a health shock, which we refer to as health transition, is generated from the following survey question: "*compared to one year ago, how do feel you about your health now? Much worse, somehow worse, the same, somehow better, and much better*". The answer to this question is used to construct three health transition dummy variables in the following way: Much Worse, which equals 1 if the answer was 'much worse' and zero otherwise; Worse, which equals 1 if the answer was 'somehow worse' and zero otherwise; and Not Worse, which equals 1 if the answer was either 'the same', or 'somehow better', or 'much better', and zero otherwise.

One caveat of using any self-reported measure of health status (SRH) is that such a measure may be an imperfect proxy of the true – but unknown – health status and may also be endogenous to labour supply. In order to account for the possibility of measurement error and potential endogeneity in SRH, we run an ordered probit regression model of SRH as a function of detailed health condition measures (using a combination of information derived from the SF-36 physical functioning index, smoking and alcohol drinking habits and other) and demographic variables. The predicted values generated by this regression are used as the measure of health stock in the analysis that follows[1].

Notwithstanding the reservations generated by the fact that SRH is a subjective measure of health, there is a large body of literature showing that SRH measure is a good indicator of health in the sense that it is highly correlated with medically determined health status (Ferraro, 1980) and is close to "objective" health (Tausman and Rosen, 1982). Gerdtham et al. (1999) show that a continuous health status measure constructed from categorical self-reported health by the method of Wagstaff and van Doorslaer (1994) is highly correlated with other continuous measures of health, such as the rating scale measure and the time trade-off measure. These studies lend considerable credence to the usefulness of the SRH measure used in this and other related papers.

The sample used in this paper contains men aged 25-64 years and women aged 25-60 years that are continuously observed throughout the six waves of the HILDA. We exclude individuals with missing observations and the full time students from the

[1] The ordered probit model is estimated separately for men and women. The results are provided in the Appendix.

sample. Our final sample consists of 22,698 person-year observations from a balanced panel of 1,822 men and 1,961 women. The summary statistics are presented in the Appendix Table A1. The working hours are measured by the total weekly hours on all jobs, where total hours includes any paid or unpaid overtime as well as any work undertaken outside the workplace. Buddelmeyer et al. (2006) report that the working hours variable in the HILDA survey has relatively better quality than other comparable Australian data sets, with fewer non-response and more consistent distribution over time.

**Table 1: Mean working hours by health status, health transition and health shock**

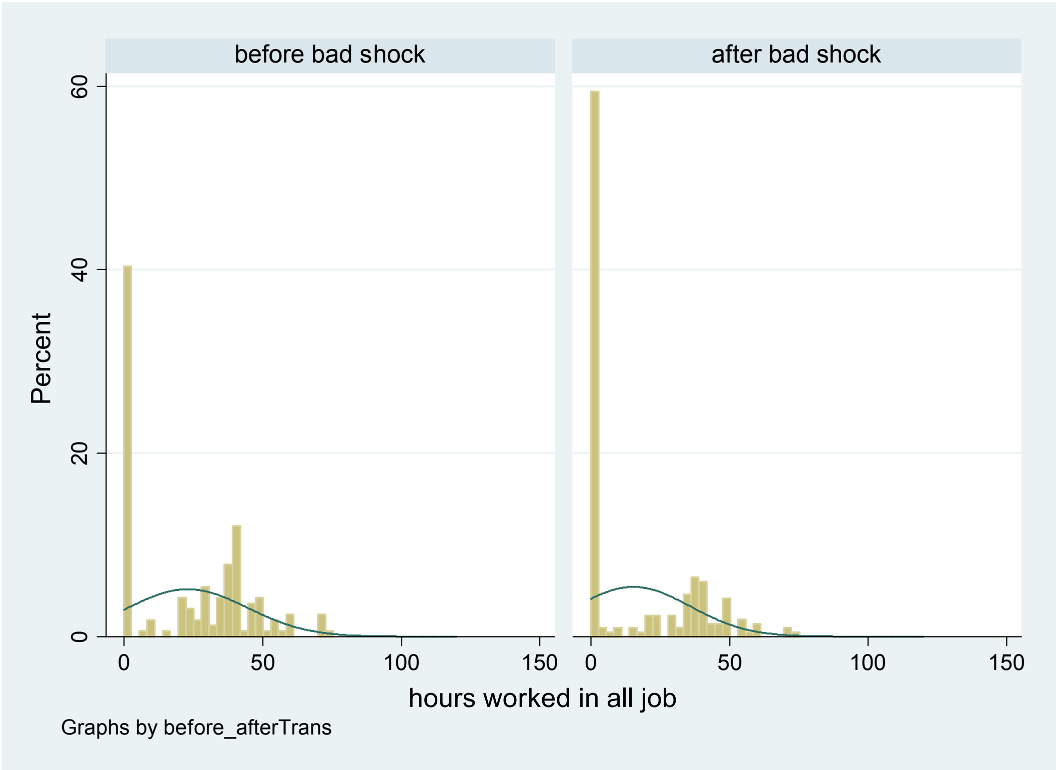
| | Mean Hours | Standard Deviation | Sample Size | Mean Hours | Standard Deviation | Sample Size |
|---|---|---|---|---|---|---|
| | Males | | | Females | | |
| **Self-reported health status** | | | | | | |
| Poor | 10.23 | 19.64 | 305 | 7.35 | 15.06 | 268 |
| Fair | 30.97 | 23.83 | 1358 | 16.86 | 19.40 | 1246 |
| Good | 40.28 | 18.43 | 4071 | 22.47 | 19.02 | 4007 |
| Very good | 42.65 | 16.07 | 4030 | 24.80 | 18.08 | 4730 |
| Excellent | 41.51 | 16.56 | 1168 | 27.05 | 18.59 | 1509 |
| **Health transition** | | | | | | |
| Much worse | 18.82 | 22.69 | 91 | 12.71 | 18.56 | 126 |
| Worse | 33.03 | 22.78 | 1110 | 20.34 | 19.54 | 1220 |
| Not worse | 40.20 | 18.49 | 9731 | 23.50 | 18.76 | 10414 |
| All | 39.29 | 19.22 | 10932 | 23.05 | 18.90 | 11760 |
| **Health shock** | | | | | | |
| Have shock | 33.87 | 23.05 | 760 | 19.62 | 19.98 | 645 |
| No shock | 39.59 | 18.78 | 8350 | 23.27 | 18.75 | 9155 |
| All | 39.11 | 19.24 | 9110 | 23.03 | 18.86 | 9800 |

Note: The health shock variable is not available for wave 1. The summary statistics for this variable use data from waves 2 to 6.

Table 1 reports the relationship between the mean working hours and the health measures in our sample.

Figure 1 below provides a picture of the impact of a 'bad' health shock on the distribution of the working hours. We identify a 'bad' health shock if an individual reports that his/her health is “much worse” compared to his/her health in the previous year.

**Figure 1: Distribution of Working Hours Before and After a ‘Bad’ Health Shock**




## 3. The Model Specification

The dynamic panel model of working hours for an individual $i$ at time $t$ can be expressed as follows,

$$y_{it}^{*} = \alpha y_{it-1} + h_{it}'\beta + x_{it}'\gamma + \mu_i + \varepsilon_{it} \qquad (1)$$

$$y_{it} = \begin{cases} y_{it}^{*} & \text{if } y_{it}^{*} > 0 \\ 0 & \text{if } y_{it}^{*} <= 0 \end{cases}.$$

Where $y_{it}^{*}$ and $y_{it}$ are latent and observed working hours respectively, $h_{it}$ is a vector containing the predicted health stock (representing the long run health status) and the two health shock measures (representing recent changes in health status, including any short-term and possibly transient changes that may not be captured by the long term health stock measure); $x_{it}$ is a vector of control variables affecting working hours;

$\mu_i$ is the individual specific unobserved heterogeneity that is assumed to be normally distributed with zero mean and variance $\sigma_\mu^2$; and $\varepsilon_{it}$ is the error term which is assumed to follow a normal distribution with mean zero and variance $\sigma_e^2$. The lagged dependent variable is included in the right hand side of Equation (1) in order to reflect the dynamic nature of working hours, in the sense that current working hours may, amongst other things, also depend on past working hours.

We estimated the model using a Tobit specification. Assuming $\text{cov}(\varepsilon_{it}, \varepsilon_{is}) = 0$ for $t \neq s$ and conditioning on $\mu_i$, we can write the probability of observing a sequence of $y_{it}$ as follows,

$$L(\mu_i) = \prod_{t=2}^{T} [\sigma_e^{-1} \phi(\Delta_{it})]^{D(y_{it}=0)} [\Phi(\Delta_{it})]^{D(y_{it}>0)} \quad (2)$$

where $\phi(.)$ and $\Phi(.)$ refer to PDF and CDF function of standard normal distribution, $\Delta_{it} = [y_{it} - (\alpha y_{it-1} + h_{it}^{'}\beta + x_{it}^{'}\gamma + \mu_i)] / \sigma_e$, and $D(.)$ is an indicator function equal to 1 if the condition in the bracket is satisfied, and zero otherwise.

The dynamic nature of model (1) implies that current working hours depend on the initial working hours, which for most of the individuals in the sample at hand predate the start of the data collection. Estimates of Equation (1) are consistent only under the assumption of exogenous initial conditions, i.e. if the first observation of working hours in the data is independent of all previous values of working hours. This is a restrictive assumption which is very likely to be violated. One solution, originally suggested by Heckman (1981), is to approximate the unknown initial conditions with a static equation that utilizes information from the first wave of the available data. The reduced form equation for the initial value of the latent dependent variable can be expressed as follows

$$y_{i1}^{*} = z_{i1}^{'}\lambda + \theta\mu_i + \varepsilon_{i1} \quad (3)$$

where $z_{i1}$ is a vector of exogenous variables including $x_{i1}$ and $\varepsilon_{i1}$ has the same distribution as $\varepsilon_{it}$. The probability of observing the initial value of the dependent variable conditional on $\mu_i$ is

$$L_1(\mu_i) = [\sigma_e^{-1}\phi(\Delta_{i1})]^{D(y_{i1}=0)}[\Phi(\Delta_{i1})]^{D(y_{i1}>0)}, \tag{4}$$

where $\Delta_{i1} = [y_{i1} - (z_{i1}^{'}\lambda + \mu_i)]/\sigma_e$.

The estimation of Equations (1) and (2) are performed jointly using the Full Information Maximum Likelihood (FIML) method.[2] The probability of observing the sequence of the dependent variables conditional on $\mu_i$ is

$$L_i = \int L(u)L_1(u)d\Phi(u) \tag{5}$$

The integral is evaluated using the Gaussian-Hermite quadrature method. Estimation has been carried out using Gauss 7.0.

## 4. Results and discussion

In this section we present estimation results for the dynamic working hours model.[3] We present a number of different specifications of Equation (1). First, we present the estimation of health stock and health shocks (or health transitions) separated from each other. Although these are not the estimation results that we wish to concentrate on, it is useful to see if and how estimates may change when the two health indicators of stock and shocks are estimated together. Second, we estimate the adverse affect of a health shock conditional on individuals' predicted health stock. The vector of control variables in *x* includes age and its square, marital status, education, the presence and the number of young children, country of birth, whether living in a capital city, job tenure and its square, and non-labour income. The estimates for the control variables are reported in the Appendix to preserve space.

Table 2 presents the core results from the health stock and health shocks variables separately estimated. Note that predicted health is measured in such a way that a higher predicted value implies better health. Results in Table 2 are largely in accordance with theory. Model I shows that lower health status (reflected in lower

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[2] The integral is evaluated using Gaussian-Hermite quadrature (Butler and Moffitt, 1982). Gauss CML library is used during the optimisation of the likelihood function.

[3] The results from the initial condition equation, model (3), are available from the authors upon request.

predicted health stock) can make work both less productive and less enjoyable, hence the positive coefficient.[4]

**Table 2: Predicted Health Stock and Health Shock Estimations**

| | *MEN* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *(I)* | | *(II)* | | *(III)* | | *(IV)* | |
| | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* |
| Health t | $3.78^{***}$ | 0.20 | - | - | - | - | - | - |
| Health t-1 | - | - | $2.90^{***}$ | 0.24 | - | - | - | - |
| Health Shock | - | - | - | - | $-3.34^{***}$ | 0.42 | - | - |
| *Health Transition* | - | - | - | - | - | - | - | - |
| Worse | - | - | - | - | - | - | $-2.50^{***}$ | 0.40 |
| Much Worse | - | - | - | - | - | - | $-11.42^{***}$ | 1.13 |
| Hours t-1 | $0.26^{***}$ | >0.01 | $0.26^{***}$ | >0.01 | $0.26^{***}$ | >0.01 | $0.26^{***}$ | >0.01 |
| | *WOMEN* | | | | | | | |
| | *(I)* | | *(II)* | | *(III)* | | *(IV)* | |
| | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* |
| Health t | $3.52^{***}$ | 0.25 | - | - | - | - | - | - |
| Health t-1 | - | - | $2.64^{***}$ | 0.25 | - | - | - | - |
| Health Shock | - | - | - | - | $-3.14^{***}$ | 0.58 | - | - |
| *Health Transition* | - | - | - | - | - | - | - | - |
| Worse | - | - | - | - | - | - | $-1.90^{***}$ | 0.45 |
| Much Worse | - | - | - | - | - | - | $-10.76^{***}$ | 1.28 |
| Hours t-1 | $0.35^{***}$ | 0.01 | $0.35^{***}$ | 0.01 | $0.35^{***}$ | 0.01 | $0.35^{***}$ | 0.01 |

Note: $^{*}$,$^{**}$,$^{***}$ refers to significance at 10%,5% and 1% respectively. Standard Errors are adjusted to correct the use of predicted health status in the estimations. All models include demographic controls. Complete results are provided in the Appendix.

Model II shows that, as one would expect, that the relationship between health status and hours worked is not all that sensitive to time, with lagged values of predicted health stock being almost as strongly associated with working hours as current values of predicted health stock. There appear to be no gender differences in these estimation results. Model III suggests that health shocks reduce working hours by about three hours on average, with little difference between the two genders. Model IV distinguishes between health shocks that make health 'worse' and 'much worse'. The strongest effect comes from the 'much worse' category of health shocks, at about 11 working hours per week average reduction, with no sizeable differences by gender. Health shocks in the 'worse' category have a much smaller effect on working hours, but are still statistically significant. This result is the only one where a trace of a

[4] The metric is not clear enough to allow us to derive a specific elasticity as health status is measured using an ordered variable. But the effect is very precisely estimated and, not surprisingly persists over time.

gender difference appears in Table 2, with a 1.9 hours reduction for women who suffered ‘much worse’ health against a 2.5 one for men, but this difference is not statistically significant at a meaningful level.

**Table 3: Health Shock conditional on Predicted Health Stock**

| | *MEN* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *(V)* | | *(VI)* | | *(VII)* | | *(VIII)* | |
| | *From II and III* | | *From II and IV* | | *From I and III* | | *From I and IV* | |
| | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* |
| Health t | - | - | - | - | 3.55$^{***}$ | 0.2 | 3.36$^{***}$ | 0.22 |
| Health t-1 | 2.82$^{***}$ | 0.24 | 2.80$^{***}$ | 0.25 | - | | - | - |
| Health Shock | -3.13$^{***}$ | 0.42 | - | - | -2.17$^{***}$ | 0.45 | - | - |
| *Health Transition* | - | - | - | - | - | - | - | - |
| Worse | - | - | -2.28$^{***}$ | 0.4 | - | - | -1.19$^{***}$ | 0.42 |
| Much Worse | - | - | -11.28$^{***}$ | 1.14 | - | - | -7.63$^{***}$ | 1.19 |
| Hours t-1 | 0.26*** | >0.01 | 0.26$^{***}$ | >0.01 | 0.26$^{***}$ | >0.01 | 0.26$^{***}$ | >0.01 |
| | *WOMEN* | | | | | | | |
| | *(V)* | | *(VI)* | | *(VII)* | | *(VIII)* | |
| | *From II and III* | | *From II and IV* | | *From I and III* | | *From I and IV* | |
| | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* | *Coeff.* | *S.E.* |
| Health t | - | - | - | - | 3.36$^{***}$ | 0.25 | 3.19$^{***}$ | 0.27 |
| Health t-1 | 2.54$^{***}$ | 0.25 | 2.53$^{***}$ | 0.25 | | | - | - |
| Health Shock | -2.74$^{***}$ | 0.59 | - | - | -2.68$^{***}$ | 0.45 | - | - |
| *Health Transition* | - | - | - | - | - | - | - | - |
| Worse | - | - | -1.60$^{***}$ | 0.46 | - | - | -0.52 | 0.48 |
| Much Worse | - | - | -10.51$^{***}$ | 1.3 | - | - | -7.20$^{***}$ | 1.38 |
| Hours t-1 | 0.35*** | 0.01 | 0.35$^{***}$ | 0.01 | 0.35$^{***}$ | 0.01 | 0.35$^{***}$ | 0.01 |

Note: $^{*}$,$^{**}$,$^{***}$ refers to significance at 10%,5% and 1% respectively. Standard Errors are adjusted to correct the use of predicted health status in the estimations. All models include demographic controls. Complete results are provided in the Appendix.

Table 3 reports the estimation results where health stock and health shock variables are jointly included into the model. Models V and VI jointly include lagged one year health stock and health shocks (or transitions) in the previous 12 months; models VII and VIII jointly include current health stock and health shocks (or transitions) in the previous 12 months. Health stock and health shocks may not be independent, in particular when self-reported health transitions are considered. Therefore, in principle, models V and VI presented in Table 3 should provide a cleaner estimate for the health shock variables than models III and IV presented in Table 2, since models V and VI control for the initial health status. However, comparing the estimates in models III and IV with those in models V and VI reveals that the effect of health shocks on working hours is only slightly reduced after conditioning on initial health status.

The most important and interesting results can be found in Models VII and VIII where the effect of health shocks that occurred in the previous 12 months is estimated conditional on current health status. These models demonstrate the dynamic nature of health shocks. If the effect of a health shock on labour supply were transitory, and/or the long-term effect of a health shock on labour supply only operated through changed health status, we would expect that, once the current health status has been controlled for, the estimate on the health shock variable would be insignificant. The estimates in Models VII and VIII show that both health shock variables used in this paper remain statistically significant after the inclusion of current health status in the equation. That is, even after conditioning on current health stock, health shocks in the previous 12 months still have a significant negative effect on the level of current labour supply. This implies that even after there has been time for a health shock to be incorporated into the individual's current health status (be that through recovery or through a long-term deterioration of health), a large proportion of the adverse effect of the health shocks on labour supply remains. This is especially so in the case of health shocks in the 'Much Worse' category, where the coefficient drops from -11.38 and -10.51 for men and women respectively in model VI, to -7.63 and -7.20 in model VIII. It is clear that severe health shocks play an important role in labour supply dynamics.

There is a number of implications related to policy that arise from the results of this paper. First, there is a clear suggestion that the effect of health on individual labour supply is not an either-or effect: people respond to health shocks by small reductions in their labour supply rather than by either leaving the labour force or not. Second, there is a clear suggestion that health shocks have an effect on labour supply which is over and above the effect of general health condition and which in the case of severe shocks can be substantial. Given the increase of the proportion of older people in the labour force and the increasing ability of medicine to prevent transient negative health shocks from becoming permanent health condition deteriorations, the relationship between health shocks and labour supply will gain importance in the future. The methodology used and results obtained in this paper will promote the discussion of policy related to the labour market rehabilitation of employees who have suffered a substantial health shock.

## 5. Conclusion

This paper examined the relationship between working hours and predicted health stock and health shocks using individual panel data from the Australian HILDA data set. The innovation of this paper is that it investigates the impact of health on the continuous variable of working hours in recognition of the fact that leaving the labour market due to low levels of health stock or due to the occurrence of new health shocks is only one of the options available to the individual. As the data shows a large proportion of those who suffer a health shock do not leave work, they simply reduce their working hours. Estimation has reconfirmed the existing result that overall lower health status results in lower working hours. The precise effect cannot be quantified with the data at hand as the health status variable is an ordinal and not a cardinal one, but this is not the focus of the paper. The paper has established that, over and above the effect that lower health status has on labour supply represented by hours worked, health shocks generate further reductions in hours worked. Estimation suggested that those who suffered a health shock that made their health 'worse' reduced their working hours by one to two hours per week on average and those who suffered a health shock that made their health 'much worse' reduced their working hours by about seven to eight hours per week. Estimation results suggest that the model performed well in separating the effects of the more time-persistent health status on working hours from the potentially more transient health shocks on working hours. Despite the very different levels of male and female working hours, estimation results do not trace any major differences in the effect of health status and health shocks on the working hours of men and women.

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# Appendix

**Table A1: Summary statistics**

| | MEN | | WOMEN | |
|---|---|---|---|---|
| *Variables* | *Mean* | *Standard Deviation* | *Mean* | *Standard Deviation* |
| Working hours | 39.29 | 19.22 | 23.07 | 18.90 |
| Health status | 2.40 | 0.93 | 2.51 | 0.92 |
| Predicted health status | 1.78 | 0.77 | 1.42 | 0.76 |
| Health shock | 0.08 | 0.28 | 0.07 | 0.25 |
| *Health Transition* | | | | |
| Much worse | 0.01 | 0.09 | 0.01 | 0.10 |
| Worse | 0.10 | 0.30 | 0.10 | 0.30 |
| Not worse$^{+}$ | 0.89 | 0.31 | 0.89 | 0.32 |
| Age | 44.77 | 9.33 | 42.92 | 8.50 |
| Married | 0.80 | | 0.77 | |
| B.A Degree or Higher | 0.26 | | 0.27 | |
| Other post-school | 0.40 | | 0.24 | |
| Year 12 | 0.10 | | 0.14 | |
| Year 11 or lower | 0.24 | | 0.35 | |
| Aus born | 0.78 | | 0.79 | |
| English speak background | 0.13 | | 0.11 | |
| Non- English speak background | 0.09 | | 0.11 | |
| Child 0-4 years old | 0.18 | | 0.19 | |
| Child 5-14 years old | 0.32 | | 0.39 | |
| Number of children | 0.81 | | 0.90 | |
| Current smoker | 0.25 | | 0.20 | |
| Ex-smoker | 0.31 | | 0.28 | |
| Heavy drinker | 0.09 | | 0.02 | |
| No physical activity | 0.09 | | 0.10 | |
| Physical function index | 87.48 | | 86.96 | |
| Long term health condition | 0.23 | | 0.20 | |
| Capital city | 0.57 | | 0.57 | |
| Family income/10000 | 8.23 | 5.92 | 7.25 | 5.42 |
| Non-labour income/10000 | 2.83 | 4.85 | 4.41 | 5.64 |
| Tenure in years | 7.99 | 9.02 | 5.27 | 7.15 |
| Sample Size | 10932 | | 11766 | |

Note: The health shock variable is not available for wave 1. The summary statistics for this variable use data from waves 2 to 6. All other figures are obtained by pooling waves 1 to 6. Non labour income is the total household income excluding the individual's labour income.

**Table A2: Effect of Predicted Health Stock**

| | *Current health* | | | | *Lagged health* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Males* | | *Females* | | *Males* | | *Females* | |
| | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. |
| Lagged hours | $0.26^{***}$ | 0.01 | $0.35^{***}$ | 0.01 | $0.26^{***}$ | 0.01 | $0.35^{***}$ | 0.01 |
| Predicted health at t-1 | - | - | - | - | $2.90^{***}$ | 0.25 | $2.64^{***}$ | 0.25 |
| Predicted health at t | $3.78^{***}$ | 0.20 | $3.53^{***}$ | 0.25 | - | - | - | - |
| (Age-25)/10 | $5.35^{***}$ | 1.21 | $2.94^{**}$ | 1.26 | $4.83^{***}$ | 1.22 | $2.75^{**}$ | 1.26 |
| Age square | $-2.61^{***}$ | 0.28 | $-1.63^{***}$ | 0.32 | $-2.53^{***}$ | 0.28 | $-1.62^{***}$ | 0.33 |
| Married | $3.75^{***}$ | 0.47 | -0.45 | 0.48 | $3.70^{***}$ | 0.47 | -0.48 | 0.49 |
| Degree | $1.88^{**}$ | 0.77 | $7.13^{***}$ | 0.73 | $2.43^{***}$ | 0.78 | $7.52^{***}$ | 0.73 |
| Other post-school education | $1.71^{***}$ | 0.58 | $4.77^{***}$ | 0.60 | $1.93^{***}$ | 0.58 | $4.89^{***}$ | 0.60 |
| Year 12 | -0.29 | 0.92 | $2.83^{***}$ | 0.81 | -0.16 | 0.93 | $3.03^{***}$ | 0.81 |
| Child 0-4 | 0.26 | 0.59 | $-7.51^{***}$ | 0.50 | 0.20 | 0.59 | $-7.50^{***}$ | 0.50 |
| Child 5-14 | -0.17 | 0.62 | 0.47 | 0.54 | -0.09 | 0.63 | 0.37 | 0.54 |
| Number of children | -0.41 | 0.33 | $-3.01^{***}$ | 0.31 | -0.42 | 0.33 | $-2.94^{***}$ | 0.31 |
| Capital city | $0.82^{*}$ | 0.45 | 0.59 | 0.44 | $1.12^{**}$ | 0.46 | 0.57 | 0.44 |
| English-speaking country | $1.55^{*}$ | 0.86 | 0.05 | 0.91 | $1.45^{*}$ | 0.86 | 0.08 | 0.92 |
| Non-English speaking country | -0.95 | 0.92 | $-2.42^{***}$ | 0.86 | -0.93 | 0.92 | $-2.50^{***}$ | 0.86 |
| Non-labour income/10000 | $-0.10^{***}$ | 0.03 | $-0.11^{***}$ | 0.03 | $-0.10^{***}$ | 0.03 | $-0.08^{***}$ | 0.03 |
| Tenure/10 | $13.35^{***}$ | 0.48 | $21.47^{***}$ | 0.54 | $13.50^{***}$ | 0.48 | $21.77^{***}$ | 0.54 |
| Tenure/10 square | $-2.50^{***}$ | 0.15 | $-5.64^{***}$ | 0.19 | $-2.52^{***}$ | 0.15 | $-5.72^{***}$ | 0.19 |
| Constant | $11.32^{***}$ | 1.40 | -0.32 | 1.36 | $13.14^{***}$ | 1.42 | 1.37 | 1.37 |
| Standard error | $10.74^{***}$ | 0.04 | $11.50^{***}$ | 0.05 | $10.76^{***}$ | 0.04 | $11.53^{***}$ | 0.05 |
| Variance of RE | $130.21^{***}$ | 5.46 | $113.19^{***}$ | 6.29 | $134.89^{***}$ | 5.57 | $115.43^{***}$ | 6.41 |
| Restricted log-Likelihood | -38909.17 | | -36065.34 | | -38951.63 | | -36101.0 | |
| Number of cases | 1822 | | 1961 | | 1822 | | 1961 | |

**Table A3: The Effect of Health Shocks and Health Transitions**

| | *Health shock* | | | | *Health transition* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Males* | | *Females* | | *Males* | | *Females* | |
| | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. |
| Lagged hours | 0.25*** | 0.01 | 0.35*** | 0.01 | 0.26*** | 0.01 | 0.35*** | 0.01 |
| Health shock | -3.34*** | 0.42 | -3.13*** | 0.59 | - | - | - | - |
| Worse | - | - | - | - | -2.50*** | 0.40 | -1.90*** | 0.45 |
| Much worse | - | - | - | - | -11.42*** | 1.14 | -10.76*** | 1.29 |
| (Age-25)/10 | 3.84*** | 1.19 | 1.90 | 1.27 | 4.09*** | 1.19 | 2.08 | 1.27 |
| Age square | -2.39*** | 0.27 | -1.51*** | 0.33 | -2.44*** | 0.27 | -1.54*** | 0.33 |
| Married | 3.84*** | 0.47 | -0.28 | 0.49 | 3.98*** | 0.47 | -0.36 | 0.49 |
| Degree | 4.01*** | 0.75 | 8.62*** | 0.73 | 4.10*** | 0.75 | 8.54*** | 0.73 |
| Other post-school education | 2.42*** | 0.58 | 5.08*** | 0.61 | 2.49*** | 0.58 | 4.94*** | 0.60 |
| Year 12 | -0.12 | 0.91 | 3.42*** | 0.83 | 0.10 | 0.92 | 3.46*** | 0.82 |
| Child 0-4 | 0.34 | 0.58 | -7.54*** | 0.50 | 0.34 | 0.58 | -7.43*** | 0.50 |
| Child 5-14 | -0.08 | 0.63 | 0.44 | 0.54 | -0.12 | 0.63 | 0.47 | 0.54 |
| Number of children | -0.47 | 0.33 | -2.83*** | 0.31 | -0.44 | 0.32 | -2.84*** | 0.31 |
| Capital city | 1.75*** | 0.46 | 0.62 | 0.44 | 1.72*** | 0.45 | 0.64 | 0.44 |
| English-speaking country | 1.45* | 0.85 | 0.29 | 0.92 | 1.44* | 0.86 | 0.25 | 0.91 |
| Non-English speaking country | -0.90 | 0.89 | -3.32*** | 0.88 | -0.86 | 0.89 | -3.24*** | 0.88 |
| Non-labour income/10000 | -0.08*** | 0.03 | -0.06** | 0.03 | -0.08*** | 0.03 | -0.06** | 0.03 |
| Tenure/10 | 13.75*** | 0.48 | 22.14*** | 0.54 | 13.74*** | 0.48 | 21.98*** | 0.54 |
| Tenure/10 square | -2.54*** | 0.15 | -5.81*** | 0.19 | -2.56*** | 0.15 | -5.75*** | 0.19 |
| Constant | 18.62*** | 1.33 | 7.01*** | 1.32 | 18.17*** | 1.32 | 6.97*** | 1.32 |
| Standard error | 10.72*** | 0.04 | 11.514*** | 0.05 | 10.72*** | 0.04 | 11.50*** | 0.05 |
| Variance of RE | 149.67*** | 5.71 | 121.68*** | 6.64 | 145.88*** | 5.66 | 119.89*** | 6.58 |
| Restricted log-Likelihood | -38980.41 | | -36129.46 | | -38965.29 | | -36112.20 | |
| Number of cases | 1822 | | 1961 | | 1822 | | 1961 | |

Note: *,**,*** refers to significance at 10%,5% and 1% respectively

**Table A4: The Effect of Health Shock Conditional on Predicted Health Stock**

| | *Current health + Health shock* | | | | *Lagged health + Health shock* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Males* | | *Females* | | *Males* | | *Females* | |
| | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. |
| Lagged hours | 0.26$^{***}$ | 0.01 | 0.35$^{***}$ | 0.01 | 0.26$^{***}$ | 0.01 | 0.35$^{***}$ | 0.01 |
| Health shock | -2.16$^{***}$ | 0.45 | -1.67$^{***}$ | 0.61 | -3.13$^{***}$ | 0.42 | -2.74$^{***}$ | 0.59 |
| Predicted health at t-1 | - | - | - | - | 2.81$^{***}$ | 0.25 | 2.54$^{***}$ | 0.25 |
| Predicted health at t | 3.55$^{***}$ | 0.21 | 3.36$^{***}$ | 0.26 | - | - | - | - |
| (Age-25)/10 | 5.29$^{***}$ | 1.20 | 2.86$^{**}$ | 1.26 | 4.84$^{***}$ | 1.21 | 2.67$^{**}$ | 1.26 |
| Age square | -2.60*$^{**}$ | 0.27 | -1.61$^{***}$ | 0.32 | -2.53$^{***}$ | 0.28 | -1.59$^{***}$ | 0.33 |
| Married | 3.68$^{***}$ | 0.47 | -0.45 | 0.49 | 3.59$^{***}$ | 0.47 | -0.47 | 0.49 |
| Degree | 1.96$^{**}$ | 0.77 | 7.21$^{***}$ | 0.73 | 2.41$^{***}$ | 0.78 | 7.57$^{***}$ | 0.73 |
| Other post-school education | 1.71$^{***}$ | 0.58 | 4.80$^{***}$ | 0.60 | 1.86$^{***}$ | 0.58 | 4.93$^{***}$ | 0.60 |
| Year 12 | -0.30 | 0.92 | 2.87$^{***}$ | 0.81 | -0.26 | 0.92 | 3.05$^{***}$ | 0.81 |
| Child 0-4 | 0.25 | 0.59 | -7.54$^{***}$ | 0.50 | 0.20 | 0.59 | -7.56$^{***}$ | 0.50 |
| Child 5-14 | -0.14 | 0.62 | 0.45 | 0.54 | -0.07 | 0.62 | 0.34 | 0.54 |
| Number of children | -0.43 | 0.33 | -3.01$^{***}$ | 0.31 | -0.46 | 0.33 | -2.93$^{***}$ | 0.31 |
| Capital city | 0.85$^{*}$ | 0.45 | 0.58 | 0.44 | 1.12$^{**}$ | 0.46 | 0.53 | 0.44 |
| English-speaking country | 1.48$^{*}$ | 0.85 | 0.05 | 0.91 | 1.37 | 0.86 | 0.10 | 0.92 |
| Non-English speaking country | -0.93 | 0.92 | -2.50$^{***}$ | 0.86 | -0.89 | 0.92 | -2.58$^{***}$ | 0.86 |
| Non-labour income/10000 | -0.10$^{***}$ | 0.03 | -0.11$^{***}$ | 0.03 | -0.10$^{***}$ | 0.03 | -0.08$^{***}$ | 0.03 |
| Tenure/10 | 13.28$^{***}$ | 0.48 | 21.47$^{***}$ | 0.54 | 13.38$^{***}$ | 0.48 | 21.74$^{***}$ | 0.54 |
| Tenure/10 square | -2.48$^{***}$ | 0.15 | -5.64$^{***}$ | 0.19 | -2.48$^{***}$ | 0.15 | -5.71$^{***}$ | 0.19 |
| Constant | 12.00$^{***}$ | 1.40 | 0.15 | 1.37 | 13.70$^{***}$ | 1.41 | 1.80 | 1.38 |
| Standard error | 10.72$^{***}$ | 0.04 | 11.50$^{***}$ | 0.05 | 10.74$^{***}$ | 0.04 | 11.52$^{***}$ | 0.05 |
| Variance of RE | 131.50$^{***}$ | 5.47 | 113.23$^{***}$ | 6.29 | 135.77$^{***}$ | 5.54 | 115.25$^{***}$ | 6.39 |
| Restricted log-Likelihood | -38895.87 | | -36054.55 | | -38931.03 | | -36090.64 | |
| Number of cases | 1822 | | 1961 | | 1822 | | 1961 | |

Note: $^{*}$,$^{**}$,$^{***}$ refers to significance at 10%,5% and 1% respectively

**Table A5: The Effect of Health Transitions Conditional on Predicted Health Stock**

| | *Current health + Health transition* | | | | *Lagged health + Health transition* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Males* | | *Females* | | *Males* | | *Females* | |
| | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. | Coefficient | S.E. |
| Lagged hours | 0.26*** | 0.01 | 0.35*** | 0.01 | 0.26*** | 0.01 | 0.35*** | 0.01 |
| Worse | -1.18*** | 0.43 | -0.52 | 0.48 | -2.28*** | 0.40 | -1.60*** | 0.46 |
| Much worse | -7.63*** | 1.19 | -7.19*** | 1.38 | -11.27*** | 1.14 | -10.51*** | 1.29 |
| Predicted health at t-1 | - | - | - | - | 2.80*** | 0.25 | 2.53*** | 0.26 |
| Predicted health at t | 3.36*** | 0.22 | 3.18*** | 0.27 | - | - | - | - |
| (Age-25)/10 | 5.33*** | 1.21 | 2.85** | 1.26 | 5.05*** | 1.20 | 2.78** | 1.26 |
| Age square | -2.60*** | 0.27 | -1.60*** | 0.32 | -2.56*** | 0.27 | -1.60*** | 0.32 |
| Married | 3.75*** | 0.47 | -0.47 | 0.48 | 3.70*** | 0.47 | -0.54 | 0.49 |
| Degree | 2.14*** | 0.77 | 7.24*** | 0.72 | 2.55*** | 0.78 | 7.52*** | 0.72 |
| Other post-sch | 1.78*** | 0.58 | 4.76*** | 0.60 | 1.90*** | 0.58 | 4.84*** | 0.60 |
| Year 12 | -0.29 | 0.93 | 2.93*** | 0.81 | -0.23 | 0.93 | 3.10*** | 0.81 |
| Child 0-4 | 0.28 | 0.59 | -7.48*** | 0.50 | 0.25 | 0.59 | -7.46*** | 0.50 |
| Child 5-14 | -0.16 | 0.62 | 0.47 | 0.54 | -0.11 | 0.62 | 0.37 | 0.54 |
| Number of children | -0.43 | 0.33 | -3.00*** | 0.31 | -0.47 | 0.32 | -2.94*** | 0.31 |
| Capital city | 0.86* | 0.45 | 0.59 | 0.44 | 1.03** | 0.45 | 0.56 | 0.44 |
| English-speaking country | 1.49* | 0.86 | 0.05 | 0.91 | 1.37 | 0.87 | 0.09 | 0.92 |
| Non-English speaking country | -0.91 | 0.92 | -2.50*** | 0.86 | -0.86 | 0.91 | -2.52*** | 0.86 |
| Non-labour income/10000 | -0.10*** | 0.03 | -0.10*** | 0.03 | -0.10*** | 0.03 | -0.08*** | 0.03 |
| Tenure/10 | 13.31*** | 0.48 | 21.42*** | 0.54 | 13.37*** | 0.48 | 21.60*** | 0.54 |
| Tenure/10 square | -2.49*** | 0.15 | -5.62*** | 0.19 | -2.49*** | 0.15 | -5.66*** | 0.19 |
| Constant | 12.10*** | 1.40 | 0.46 | 1.37 | 13.40*** | 1.40 | 1.81 | 1.38 |
| Standard error | 10.72*** | 0.04 | 11.49*** | 0.05 | 10.73*** | 0.04 | 11.50*** | 0.05 |
| Variance of RE | 130.54*** | 5.47 | 112.77*** | 6.30 | 133.24*** | 5.51 | 114.43*** | 6.36 |
| Restricted log-Likelihood | -38895.87 | | -36054.5538 | | -38915.36 | | -36073.18 | |
| Number of cases | 1822 | | 1961 | | 1822 | | 1961 | |

Note: *,**,*** refers to significance at 10%,5% and 1% respectively

**Table A6: Ordered Probit Results, Self Reported Health**

| | *MEN* | | *WOMEN* | |
|---|---|---|---|---|
| *Variables* | *Coefficient* | *S.E.* | *Coefficient* | *S.E.* |
| Age | -0.27*** | 0.05 | -0.21*** | 0.05 |
| Age square | 0.06*** | 0.01 | 0.04** | 0.01 |
| Married | -0.04 | 0.03 | -0.07** | 0.03 |
| BA or higher | 0.19*** | 0.03 | 0.11*** | 0.03 |
| Other post school | 0.07** | 0.03 | 0.01 | 0.03 |
| Year 12 | 0.11*** | 0.04 | 0.07** | 0.03 |
| Eng. Speaking Background | 0.00 | 0.03 | 0.00 | 0.03 |
| NonEng. Speaking Background | 0.00 | 0.03 | -0.17*** | 0.03 |
| Current smoker | -0.32*** | 0.03 | -0.32*** | 0.03 |
| Ex-smoker | -0.11*** | 0.03 | -0.08*** | 0.02 |
| Drink Alcohol | -0.13*** | 0.04 | -0.13** | 0.06 |
| No physical Activity | -0.42*** | 0.04 | -0.30*** | 0.03 |
| Physical Functioning Index | 0.25*** | 0.01 | 0.27*** | 0.01 |
| Long term health condition | -0.66*** | 0.03 | -0.69*** | 0.03 |
| Capital city | 0.10*** | 0.02 | -0.06*** | 0.02 |
| Family Income | 0.10*** | 0.04 | 0.28*** | 0.03 |
| Family Income Square | 0.00 | 0.01 | -0.03*** | 0.01 |
| | | | | |
| *Cut-off Points* | | | | |
| m0 | -0.88*** | 0.07 | -0.81*** | 0.07 |
| m1 | 0.52*** | 0.07 | 0.52*** | 0.07 |
| m2 | 1.92*** | 0.07 | 1.91*** | 0.07 |
| m3 | 3.28*** | 0.07 | 3.32*** | 0.07 |
| Restricted log-Likelihood | -12417.3 | | -13235.6 | |
| Number of cases | 1822 | | 1961 | |

Note: *,**,*** refers to significance at 10%,5% and 1% respectively. The estimation results are obtained using a pooled sample of HILDA waves 1 to 6.