The Economic Determinants of Physical Activity Behaviour: Evidence from the Household Income and Labour Dynamics in Australia (HILDA) Survey

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Abstract: This paper uses the first six waves (2001-2006) of the Household Income and Labour Dynamic in Australia (HILDA) survey to investigate the demographic and economic factors that influence physical activity behaviour. A modified time allocation framework and a variety of econometric techniques are used to better understand the factors that influence how individuals choose to allocate part of their leisure time to participating in physical activity. Results show that gender moderates many of the factors that influence physical activity behaviour such as age, the presence of dependent children, household income, education, and health. For both men and women, working full time, being married or in a committed relationship, and living in an urban environment negatively impact the likelihood of regular physical activity participation.

I. Introduction

Participating in regular physical activity has been shown to improve health, emotional well-being, and worker productivity. According to estimates by the World Health Organisation (WHO) (2004), 1.9 million deaths worldwide are attributable to physical inactivity and a sedentary lifestyle. At least thirty minutes of moderate physical activity[1] five days a week reduces the risk of coronary heart disease, stroke, type II diabetes, and, specifically for women, the risk of colon and breast cancer (CDC 1996, WHO 2004). There is also evidence that physical activity may reduce hypertension, as well as the negative symptoms and pain associated with musculoskeletal conditions such as osteoarthritis and lower back pain, and help maintain a healthy body weight and composition (see for example, Haskell et al. 2007, WHO 2004, and Hildebrandt et al. 2000). Physical activity may also help emotional well-being by reducing stress, anxiety, and depression (WHO 2004 and Milner 2007). These emotional and physical health benefits of physical activity can also lead to increased productivity at work through lower absenteeism and turnover (WHO 2004).

Because of both the potential adverse health and labour market effects of a sedentary lifestyle, increasing physical activity participation of working age adults is an essential goal for both the public and private sector. Currently, physical activity levels remain low amongst individuals living in developed countries (Kafatos et al. 1999). It has been found that efforts to promote participation in physical activity are more likely to be effective if they address the needs and interests of a particular target group (Booth et al. 1997). Therefore, this paper aims to better understand the physical activity behaviour of working age adults from an economic perspective. This study will use panel data from Australia to analyse the individual determinants of physical activity participation by gender.

There is extensive public health literature examining physical activity participation of adults (for example Vaughn et al. 2008, Booth et al. 1997, Chau et al. 2008); however this issue has not been

[1] Moderate physical activity is defined as an activity that uses large muscle groups and is at least equivalent to brisk walking. Some examples are dancing, cycling, gardening, and swimming (CDC 1996).

extensively addressed from an economic perspective. The decision to participate in physical activity is an individual choice partially based on economic, social, and environmental factors. Therefore, core economic principles which have been designed and used for modelling responses to incentives as well as time trade-offs can be used to explain physical activity behaviour (Mavromaras 2008). A better understanding of the economics behind an individual's physical activity behaviour can help policy makers create effective policy to promote regular physical activity and a healthy population.

The analysis undertaken in this chapter uses the first six waves (2001-2006) of the Household Income and Labour Dynamics in Australia (HILDA) survey to determine what economic factors and individual characteristics influence the decision to participate in physical activity. Differences in physical activity behaviour by gender are explored. The econometric analysis involves several estimation techniques to determine how individuals choose to allocate their time between market work, non-market work, and leisure which includes physical activity.

The structure of this paper is as follows. Section 2 describes the theoretical framework which forms the basis for the empirical analysis. Section 3 explains the econometric approach and Section 4 outlines the data and variables. The results are presented in Section 5. Finally, Section 6 proposes areas for further research and concludes.

2. Theoretical Framework

The starting point in determining the amount of time spent on physical activity is Becker's (1965) seminal paper on the allocation of time. A household production function is formulated that comprises the activities of market work, non-market work such as childcare, and leisure. Becker's original model is extended in this chapter to include physical activity as a leisure activity. Leisure time physical activity is assumed to be the most effective type of physical activity to focus on for policy purposes as manual labour which may embody some physical activity, is now uncommon in industrialized economies[2] (Hardman and Stensel 2003). The household maximises a utility function defined over these three activities so that in equilibrium the marginal value of household production, the marginal rate of substitution between consumption and leisure activities (including physical activity) and the market wage rate are equal (van den Brink and Groot 1997). To simplify the model it is assumed that physical activity does not have a direct effect on wages as was described in the dynamic framework of Suen and Mo (1994). In other words, the sole output of physical activity is utility[3]. The household production model is an adaptation of the model proposed by van den Brink and Groot (1997)[4]. The model begins with the customary utility function:

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[2] According to data from the 2006 Census of Population and Statistics from the Australian Bureau of Statistics (ABS), only 12% of men and 1% of women are employed in manual occupations.

[3] This assumption is relaxed in the empirical analysis

[4] In van den Brink and Groot (1997) the model is used to explain the allocation of time between child care, market work, and leisure. The model is adopted here to distinguish between market work, non-market work, and leisure which includes physical activity.

U=U(Z,L) (1)

where utility (U) is a function of (Z) which is the consumption of commodities within the household and leisure (L). This reduced form utility function represents the influences of both preferences and technology on the consumption decision.
The optimisation of the utility function is subject to a budget constraint and time constraint:

$$\sum_{i=1}^{M} p_i x_i \leq I = m_o + wN \text{ and } L+N+H_z = T \qquad (2)$$

where $p_i x_i$ is defined as the price of consumption, I is total income, m_0 is non-labour income and wN is labour income, or in other words the hourly wage rate, w times the amount of hours worked, N. Prices, non-labour-income, wages, and labour supplied affect the position of the budget constraint. For the time constraint, T denotes the total time available which is divided between hours worked (N), leisure (L), and time spent on home production or non-market work (H_z).

From the budget and time constraints one can derive the full income constraint:

$$X+wN+wH_z=wT+m_0=F \qquad (3)$$

In this case, F is full income or the total income available to allocate between consumption of market goods, leisure, and non-market production such as child care.

Maximisation of the utility function yields the first order conditions of the model. For the interior allocation in the time use spaces, where $0<N<T$, $0<H_z<T$, and $0<L<T$, one can show that:

$$\frac{\left(\frac{\partial U}{\partial L}\right)}{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial X}\right)} = \frac{\left(\frac{\partial U}{\partial L}\right)}{\left(\frac{\partial U}{\partial X}\right)} = W \qquad (4)$$

Since $\frac{\partial Z}{\partial X} = 1$ or household commodities and market goods are perfect substitutes, one can then derive the marginal rate of substitution between leisure (L) and commodities (Z):

$$\frac{\left(\frac{\partial U}{\partial L}\right)}{\left(\frac{\partial U}{\partial Z}\right)} \tag{5}$$

Equation (4) also yields the marginal value of non-market work:

$$\frac{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial H_Z}\right)}{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial X}\right)} = \frac{\partial Z}{\partial H_Z} = W \tag{6}$$

Traditionally women spend more time partaking in certain non-market activities, such as childcare and cooking, than men (Jaumotte 2003); therefore they may place a lower value on market work. Thus, it is expected that women and men will have different optimal amounts of physical activity consumption as they will choose to allocate different amounts of time to leisure, work, and non-market work.

2.1 Physical Activity Participation and Endogeneity

In this sub-section the assumption, that the sole output of physical activity consumption is utility, is relaxed. It is now assumed that the consumption of physical activity is a joint product that produces utility as well as contributing with other health related inputs, to the production of health (Grossman 1972). Thus, it is expected that those who participate in regular physical activity are likely to be in better health and also that those who are in better health are more likely to participate in physical activity to maintain their health capital. It is also likely that regular physical activity may lead to higher wages, if individuals who participate in regular physical activity are more productive; for example, there is evidence that workers who engage in physical activity have lower rates of absenteeism than those who do not participate in regular physical activity (WHO 2004).

It is probable that there are unobserved effects such as a genetic endowment component which will also impact on both physical activity participation and health. For example, if the individual suffers from a genetically related health condition which results in poor overall health this may limit their physical activity participation. Motivation and skill are two other unobserved characteristics which may impact on both physical activity participation and wages. The potential endogeneity of health, wages, and unobservable effects will be addressed in the econometric framework section (Section 3).

2.2 Physical Activity Participation and the Built Environment

There is some evidence that the built environment may act as a barrier to participating in physical activity if individuals do not have access to parks, cycling and walking paths, and other sports facilities near by (Transportation Research Board 2005). Especially for women, the character of the neighbourhood may influence the likelihood of participating in outdoor physical activity. Saelens et al. (2003) found that neighbourhoods with high crime rates, boarded up shop fronts, and poorly maintained infrastructure discouraged walking and cycling. Rural respondents particularly men, may be more likely to be employed in manual professions such as farming which could impact on their physical activity participation. In the econometric model, we control for type of occupation, type of geographical area, and socioeconomic disadvantage of the area in order to deal with these issues.

3. Econometric Framework

A number of econometric techniques will be used in the analysis to establish the factors that significantly impact on physical activity behaviour. Firstly, random effects probit and random effects logit model are estimated. These two specifications are estimated as a robustness check on the results as the two regression models have different normalization assumptions. Next, in order to check for the importance of heterogeneity of the individual unobserved effects on the results, a probit specification using the Mundlak approach (Mundlak 1978) and a fixed effect logit model are estimated. To determine the most appropriate model a Hausman test is performed to compare the parameters obtained from the random effects logit model with the fixed effects logit model.

The equations are estimated separately for men and women. Firstly, the random effects probit model is estimated:

$$Y_{i,t}^{*} = X_{i,t}^{'}\beta + \gamma Z_i + \psi R_{i,t} + \xi H_{i,t} + \varsigma H_{i,t-1} + \nu_{i,t} \qquad (7)$$

where *i=1,2,….n and T = 1,….,T*

$$\nu_{i,t} = \alpha_i + u_{it}$$

$Y_{i,t} = 1$ if $Y_{i,t}^{*} > 0$ or zero otherwise.

Let $Y_{i,t}^{*}$ represent an individual's (*i*) unobservable propensity to participate in physical activity in each time period (*t*) which can be equal to zero. From this, $Y_{i,.t}$ is a binary indicator for the observed level of physical activity by individual (*i*) in period (*t*). $X_{i,t}$ is a vector of time variant individual characteristics such as age, hourly wage, number of small children, where β is the vector of coefficients associated with X[5]. Z_i is a vector of time invariant individual characteristics such as country of birth with the associated vector of coefficients,

[5] Lagged hourly wage is included in some model specifications in an attempt to reduce potential endogeneity problems.

γ. $R_{i,t}$ is a vector of variables related to the built environment such as region and the level of socio-economic deprivation of the area, with the associated vector of coefficients, ψ. $H_{i,t}$ is a vector of health characteristics such as the SF6D health measure (Brazier et al 2002) as well as a self-assessed health measure as a comparison to the more objective SF6D index. The associated vector of coefficients is ξ. A lagged health variable $H_{i,t-1}$ is included in some estimations of the model in an attempt to reduce potential endogeneity problems, with the vector of coefficients, ζ. α_i denotes the individual specific unobservable effects and u_{it} is a random error term.

For the random effects probit model it is assumed that $u_{it} \sim IN(0,\sigma_u^2)$, the error term is independently and normally distributed, and $\alpha_i \mid X_i, Z_i, R_i, H_i \sim IN(0,\sigma_\alpha^2)$ or the individual error component, conditional on the explanatory variables, is independent and normally distributed. The latter is a strong assumption as it assumes not only the normal distribution of α_i but that α_i is independent of *X*, *Z*, *R*, and *H* (Wooldridge 2002).

Next, a random effects logit model is estimated. This model is also estimated using equation (7). However, the error term is now assumed to be logistically distributed so that: $u_{it} \sim I\Lambda(0,\sigma_u^2)$ and $\alpha_i \mid X_i, Z_i, R_i, H_i \sim I\Lambda(0,\sigma_\alpha^2)$. The logistic distribution has fatter tails in the z-distribution than the random effects probit specification; however the two models should produce similar results if the distribution of sample values of $Y_{i,.t}$ is not too extreme (Baum 2006).

The random effects binary response model imposes the restriction that the individual effects $\alpha_{i,}$ are independent of the observed explanatory variables. It is likely that this assumption will not hold true if, for example, some of the unobserved individual characteristics which impact on health also influence physical activity participation or if other potential individual effects such as skill, motivation, and determination are correlated with some of the explanatory variables like education or occupation. If this is the case, then the random effects probit model will not give consistent estimates of the parameters: β,γ,ψ, and ξ. Therefore, in order to account for the impact of the individual effects on both the dependent and explanatory variables, a fixed effects model is a more appropriate specification. Here we use two methods: a fixed effects logit and the Mundlak method[6].

The Mundlak method accounts for the positive correlation between the explanatory variables X_i, Z_i, R_i, H_i and the individual effects α_i by modelling the dependence between α_i and the regressors explicitly. Modelling this dependence allows for unbiased estimation of β,γ,ψ, and ξ regardless of whether

[6] While a fixed effects probit is in many ways the 'ideal' model it is not easily estimated. There are potentially a limitless number of (n+K)-n parameters to be estimated. Therefore, to estimate the parameters of the model it will be necessary to compute the possibly huge number of constant terms at the same time. This presents a practical obstacle to estimation of the model as there is a need to invert a potentially large second derivative matrix (Green 2003, Madala 1987). For this reason, there is no explicit command in STATA to estimate a fixed effect probit model.

or not $X_{i,}$ Z_i, R_i, H_i and α_i are independent. Mundlak (1978) suggests modelling the inclusion of group meansby estimating $\alpha_i = \varphi \bar{X}_i \kappa \bar{H}_i + u_i$. The model estimated is then:

$$Y_{i,t}^{*} = X_{i,t}' \beta + \varphi \bar{X}_i + \gamma Z_i + \psi R_{i,t} + \xi H_{i,t} + \kappa \bar{H}_i + \nu_{i,t} \tag{8}$$

where *i=1,2,….n and T=1,….,T*

$$\nu_{i,t} = \alpha_i + u_{it}$$

Where $\bar{X}_i$ is the mean of the continuous individual characteristics variables of hourly wage, household income, age, and age squared. $\bar{H}_i$ is the mean of the SF6D variable for individual i. The error term ν_{it} takes into account the inclusion of the group means in α_i to remove the problem of individual heterogeneity. The other variables are defined as in equation (7). This specification assumes that the individual effects are linearly related to the explanatory variables. (Jones et al .2007).

The second method to deal with individual heterogeneity is a fixed effect logit specification. This approach finds the joint distribution of $Y_i \equiv (Y_{i1,} \ldots Y_{i6})'$ conditional on $X_i, Z_i, R_{i,} H_i$, and $n_i \equiv \sum_{t=1}^{T} Y_{it}$. This conditional distribution does not depend on the individual effects, $\alpha_{i,}$ so that it is the distribution of Y_i given $X_i, Z_i, R_{i,} H_i$ and n_i. Therefore, standard conditional maximum likelihood methods can be used to estimate the parameters β,γ,ψ, and ξ in equation (7) (Wooldridge 2002).

The fixed effect logit specification relies on observations where the dependent variable changes over time, as the model conditions on those observations that make a transition from either (0,1) or (1,0) and discards those that are (0,0) or (1,1) for the duration of the panel (Jones 2007). In other words, we need people to make the transition to and from participation in regular physical activity to be included in the regression sample. This explains the smaller sample sizes found in the estimations of the fixed effect logit models. In order to ensure, that the fixed effect logit model provides consistent estimates of the parameters one must test for heterogeneity. One such method is the Hausman test which compares the random effects logit or the null hypothesis that $(\alpha_i = \alpha)$ to the alternative hypothesis of heterogeneity (fixed effects logit).

In order for the parameter estimates from the binary response models to be easily interpreted the marginal effects are calculated. The marginal effects for the fixed and random effects logit specification calculate the probability of a positive outcome, assuming that the fixed effects (α_i) for the observations panel are zero. This may not be similar to the proportion of observed outcomes in the group, if there are not many transitions between the states of physical inactivity and regular physical activity.

3.1 The Endogeneity of Health and Wages on Physical Activity Participation

The Mundlak approach and the fixed effect logit model, which remove the time invariant individual effect of the health[7] and hourly wage variables from the model by taking the mean of these two variable, eliminates one source of potential endogeneity bias caused by the correlation between unobserved individual specific effects, health, and wages. A second method of reducing the bias caused by the potential endogeneity of health is to include a lagged health and wage variable in the regression equations. This accounts for the possible endogeneity between current health, wages and physical activity caused by simultaneous causations but does not control for potential endogeneity between lagged health, lagged wages, and current physical activity participation.

4. The Data

The empirical analysis in this chapter uses the first six waves of the Household, Income, and Labour Dynamics in Australia (HILDA) survey which covers the period 2001-2006. The HILDA survey is a nationwide household panel survey with a focus on issues relating to families, income, employment, and well-being. Survey methodology and the motivation behind the creation of the HILDA survey is described in greater detail in Watson and Wooden (2004). The first wave of the survey was conducted between August and December 2001, where 7682 households representing 66 percent of all in-scope households were interviewed, creating a sample of 15,217 individuals over the age of 15 eligible for an interview of whom 13,969 were successfully interviewed. Subsequent interviews were conducted approximately one year apart. As with other household surveys, the sample is extended each year to include any new household members resulting from changes in the composition of the original household. In wave 6, there were a total of 12,905 individuals who were successfully interviewed.

In order to determine if non-random, non-response will bias the estimation results a simple test proposed by Verbeek and Nijman (1992) is used. Variables accounting for the response status of individual respondents that are reflected in the vector $q_{i,t}$[8] are added to the random effects probit model estimated in equation (8). The statistical significance of the variables in vector $q_{i,t}$ provide a test for non-response bias. The equation is estimated using an unbalanced panel. A Wald-test is then performed. If the null hypothesis of *Prob(chi2<0.05)* is not rejected then it is assumed that non-response is random. This implies that indicators of an individual's pattern of non-response, q_i is not associated with the outcome of interest (physical activity participation) after controlling for the observed covariates in X_i, Z_i, R_i, H_i (Jones et al. 2007).

[7] The SF6D measure.

8 Three separate variables are created that indicate whether the individual 1) appears in the next wave, 2)t he balanced panel, and 3) the total number of waves for which the respondent is present.

4.2 Dependent Variable

The WHO (2004) and CDC (1996) find that the health benefits of physical activity are associated with participating in vigorous physical activity three days a week or moderate physical activity five times a week, or in other words 150 minutes per week of a combination of moderate and vigorous activity. Using this definition, regular physical activity for this analysis is defined as participating in moderate physical activity for 30 minutes five or more days a week or intense physical activity for 30 minutes three or more days a week.

In order to investigate the physical activity behaviour of working age adults the dependent variable used in this analysis is a binary indicator which equals one if the individual participates in regular physical activity and zero otherwise. We choose the binary classification because participating in physical activity less than three times a week may not positively impact health, well-being, or productivity (Hardman and Stensel 2006). Thus, in order to create effective policy to promote a healthy population it is important to determine what factors increase the likelihood of participating in medically defined regular physical activity.

The potential bias in self-reported variables has been widely discussed in the economics literature (for example Lindeboom 1998 and Bound 1991 have analysed self-assessed health). However, the issue of bias in self-reported physical activity has mostly been addressed in the epidemiology and public health literature (Aires et al. 2003 and Adams et al. 2005). A potential problem with this literature is that many studies tend to use a small, narrowly defined, dataset which limits the ability to compare this work with a more general population. This literature analyzes the problems of recall bias, misinterpretation of the survey question, and answering the question to adhere to perceived social norms regarding exercise behaviour. This will affect the estimation results if the occurrence of these three factors is not random. Aires et al. (2003) find the self-reported physical activity variable to be valid in a population of individuals aged 40-42 in Norway. Adams et al. (2005) in a sample of 81 American women find that the social desirability of physical activity may lead to an overestimation of exercise participation but it is independent of body size. The physical activity levels reported in the HILDA survey is also compared with other nationally representative surveys concerned with physical activity behaviour to help confirm the validity of the variable. Appendix A compares mean physical activity levels for all six years of the HILDA survey with four cross-sectional and longitudinal national and regional studies. The percentage of men and women who participate in regular physical activity is similar across these national and regional representative samples. Thus, one can assume that physical activity results from the HILDA survey should not suffer from any bias relative to other Australian surveys.

4.3 Explanatory Variables

Table 1 presents a complete list of variables and definitions used in the regressions. The analysis includes time-varying variables to determine the factors that influence physical activity behaviour. It is possible that time variant variables may only temporarily impact exercise behaviour or signal a gradual change in existing behaviour.

5. Results and Discussion

Two different estimation specifications are presented in Tables 2 and 3 to check the robustness of the results, determine if individual heterogeneity effects the analysis, and test how the inclusion of potentially endogenous variables affect the magnitude and significance of the coefficients of the other variables in the equations. Firstly, a model is estimated in Table 2 that includes only the variables in vectors $X_{i,t}$ and $R_{i,t}$ (individual characteristics and built environment variables) from equations (7) and (8) to test how these variables affect the likelihood of participating in regular physical activity. Next, a model is estimated in Table 3 that includes the health variables in vector $H_{i,t}$ along with the variables in vectors $X_{i,t}$ and $R_{i,t}$ to determine the role that health plays in the decision to participate in regular physical activity as well as testing how the addition of the health variable changes the magnitude and significance of the explanatory variables included in the vectors $X_{i,t}$ and $R_{i,t}$. The results from the Mundlak approach probit are similar to the random effects probit model and are therefore not present in the tables[9]. Table 4 reports the results for the estimation specification which focuses on controlling for potential endogeneity in both the health variable and the wage variable. The Verbeek-Nijman test for attrition in Table 5 shows that non-random sample selection should not bias the results. The Hausman type test for individual heterogeneity does not reject the null-hypothesis that the random effects model is the most efficient specification. It is possible that time variant unobserved effects such as feeling tired or overworked play a bigger role in determining physical activity behaviour than unobserved individual effects such as skill and motivation.

Gender moderates many of the factors that influence physical activity behaviour. The likelihood of participating in regular physical activity significantly decreases with the continuous age variable in all model specifications for men. The age squared variable has a small and positive effect on the likelihood of men participating in regular physical activity. These results suggest a U-shaped relationship between being physically active and age for men of working age. The male results are consistent with Farrell and Shields (2002) who also found a significant negative relationship between age and male sporting participation. Whereas for women, there is an inverse U-shaped relationship for the age and age squared variable with age having a negative effect on the likelihood of regular physical activity participation and age squared having a small positive insignificant effect.

For men, in Table 2 none of the coefficients on the education variable are significant. In Table 3, having a diploma or advanced diploma has a negative and significant impact on the likelihood of regular physical activity participation in the male equations. These results are inconsistent with much of the

[9] They are available by request from the author.

Australian literature which have analysed the effects of education on physical activity participation (Armstrong et al. 2000, Bauman et al. 2001, and Stratton et al. 2005). These studies have found a positive effect of education on physical activity participation. However, as one is not able to distinguish in the HILDA survey between leisure time physical activity and work based physical activity it is possible that the education variable is capturing some of the effects of employment based physical activity. For women having a diploma or advanced diploma compared to the base category of no educational qualifications has a positive and significant effect on the likelihood of participating in regular physical activity in the random effects specifications. The female results that higher levels of education increase the likelihood of physical activity participation is consistent with the Australian literature (Armstrong et al. 2000, Bauman et al. 2001, and Stratton et al. 2005). There is not likely to be much within individual variations in the education variable which may explain the insignificance of education in the fixed effects specifications. It is also possible that education may be correlated with income and some of the other socio-economic status variables which may impact the results.

Household income does not significantly impact the likelihood of men participating in regular physical activity in Tables 2 and 3. The household income variable is small, positive, and significant in all model specifications for women. The magnitude of the coefficients on the household income variable is approximately the same in both tables. This result may suggest that a higher household income allows women to invest in time saving devices around the house which reduce the amount of time that needs to be spent on non-market work (Berndt 1991).

If the income effect dominates and individuals with a higher wage choose to devote more time to work, one would expect a higher hourly wage to have a negative effect on the likelihood of participating in regular physical activity whereas the opposite would occur if the substitution effect dominates. The hourly wage variable has a negative effect on the likelihood of participating in physical activity in the male equations in both tables. For the female equations the coefficient on the hourly wage variable is positive in all model specifications. This variable is not significant for either gender in any of the model specifications. Interestingly, the hourly wage variable appears to be independent of health as there is no real change in the magnitude of the coefficient on the hourly wage variable from Table 2 to Table 3. This may suggest that once an individual chooses to work, health does not impact wage which corresponds with findings from the health literature (Currie and Madrian 1999). These results may also imply that once individuals choose to work full-time, the wage rate does not influence how time is allocated. The lagged wage variable in Table 4 is not significant for either gender. The magnitude of the coefficient on lagged wage and current wages are roughly the same for both genders suggesting that wages and health may not be endogenously related. This also suggests that past wages do not influence current physical activity participation.

Working full-time compared to the base category of non-participation has a negative and significant effect on the likelihood of participating in regular physical activity in all of the random effect model specifications. The unemployed category was dropped from both the male and female sample because of collinearity in all model specifications in Tables 2 and 3. This variable is not significant in the fixed effect specification which may be due to insufficient within individual variation in this variable. The magnitude of the female coefficient for full-time employment variable is smaller than in the male regressions in both tables; implying that this effect is independent of health. The results may reflect the fact that fewer women then men in the sample are employed full-time. In terms of the literature, Nomaguchi and Bianchi (2004) also found that full-time employees spend less time exercising than their part-time counterparts.

Working in a manual job compared to working in any of the other seven classes of occupations[10] has a positive and significant effect on the likelihood of participating in regular physical activity for both genders. This may suggest that those employed in manual jobs may include employment based physical activity when responding to the physical activity question in the HILDA survey. The magnitude of the coefficient on the manual labour variable is smaller in the female equations than in the male equations in both tables; this may be because most women employed in manual occupations are doing less strenuous jobs such as cleaning compared with their than their male counterparts who are more likely to have jobs that involve heavy lifting which could impact the amount of physical activity they participate in on a weekly basis. The magnitude and significance of the manual occupation variable does not vary widely in the two tables suggesting that this variable is independent from health and the additional individual characteristics variables.

Compared to the base category of separated, divorced or widowed, being legally married or cohabiting has a significant and negative impact on the likelihood of participating in regular physical activity for men in the random effects specifications. The negative coefficients on the marriage variable are greater in Table 2 for men suggesting that there may be a relationship between marriage, health, and the additional explanatory variables. Numerous studies have found a positive relationship between marriage and health (see for example Lillard and Panis 1996). For women being single has a positive and significant effect on physical activity participation in the random effects specifications. This effect is greatest in Table 2 or the model which does not include health suggesting that health and marital status may be related for women. The female results may imply that single women have fewer time commitments and thus can devote more time to physical activity as was proposed by MINTEL (2000) to explain the higher rates of sport participation by single individuals.

The presence of dependent children under the age of four significantly reduces the likelihood of participating in regular physical activity for both genders. This is consistent with findings in the literature such as Farrell and Shields (2002), Brown and Trost (2003), and Bell and Lee (2005) which show that there is a negative relationship between parenthood and physical activity. It is expected that young dependent

[10] The other types of occupations are 1) managerial; 2)professional; 3) associate professional; 4)trade work; 5) intermediate services; 6) intermediate production; and 7) elementary work.

children require a lot of time and attention which could mean that parents of young children devote more time to these non-market responsibilities and less time to leisure and physical activity. Physical activity transitions during parenthood may be moderated by gender with mothers experiencing the largest decline, as women are traditionally the primary caregivers (Bellows-Rieken and Rhodes 2007). The magnitude of the coefficient on preschool age children is larger for women than men. Children aged five to fifteen do not significantly impact the likelihood of men participating in regular physical activity whereas the presence of dependent children between the ages of five and fifteen significantly reduces the likelihood of regular physical activity participation for women. The magnitude of the coefficient on this variable is consistent through out the two tables for both genders. Nomaguichi and Bianchi (2004) found that mothers on average spend one hour and twenty six minutes less on physical activity per week than fathers. Dependent children aged 15 plus do not significantly impact the likelihood of participating in physical activity for either gender.

The built environment variables have a similar effect on both genders. Living in a capital city compared to living in any other part of the eight states and territories significantly reduces the likelihood of participating in regular physical activity. These results are consistent through out the two tables. There are two possible explanations for this finding. If the urban environment has a lack of parks, cycle paths, etc. this may act as a barrier for physical activity participation which implies that incorporating green spaces into cities is important for promoting physical activity. An alternative explanation is that individuals living in more remote areas may use physical activity as means to facilitate social interactions with neighbours and friends. Stratton et al. (2005) found for an Australian population that those living in inner regional (suburban areas) were more likely to participate in physical activity than major urban dwellers.

Living in an area of low socioeconomic deprivation compared to living an area of high socioeconomic deprivation has a positive and significant effect on physical activity participation for both genders. The magnitude of the coefficients on this variable is roughly the same for both genders and in Tables 2 and 3 suggesting gender differences do not play a role in how socioeconomic deprivation affects physical activity participation. The results also imply that socioeconomic deprivation appears to be in independent of health which is inconsistent with some of the literature that has found a significant relationship between social deprivation and health (Eames et al. 1993).

Now, specifically focusing on Table 2, the SF6D health index, significantly impacts the likelihood of participating in regular physical activity for both genders. Better health increases the likelihood of participating in physical activity. These results are consistent with the medical literature (for example World Health Organisation (WHO) 2004, Center for Disease Control (CDC) 1996, Milner 2007, Hildebrandt et al 2000) which show a positive relationship between health and regular physical activity. The effect of better health as measured by the SF6D index is greater for women than for men. Thus, health may play a bigger role in women's physical activity decision. It is also worth noting that the SF6D index varies widely in columns 1, 2, and 3. It is likely that the different normalisations of the models influence the results; the logistic distribution (columns 1 and 2) has fatter tails. Unobserved effects such as genetic endowment may also influence the relationship between health and physical activity.

In order to account for this potential endogeneity a lagged self assessed health variable and a lagged SF6D health variable are included in the regression equations. The results for lagged health are presented in Table 4. The lagged self-assessed health states have a significant and negative impact on current physical activity participation for both genders whereas the lagged SF6D variable has a positive and significant effect on the likelihood of participating in regular physical activity. The coefficients on the lagged health variables are smaller than those of the current health states. As one would expect, lagged health controls for some of the endogeneity of current health on physical activity participation, the magnitude of the coefficients on current health states are smaller than those in Table 3. These results suggests that current health impacts physical activity participation but there is high serial correlation between physical activity and health so that even when past health states are used as a regressor the effect of health on physical activity participation is still significant.

Overall, the inclusion of health does not significantly change the magnitude and significance of the coefficients in Table 2 which suggest that the potentially endogenous relationship between health and physical activity participation should not bias the results.

6. Conclusion

This paper aims to determine the factors which influence the physical activity behaviour of working age individuals in Australia using a modified time allocation framework and a variety of econometric techniques. The results highlight many of the barriers to physical activity participation in this important demographic group. Many of the factors which affect the time allocated to physical activity participation are moderated by gender such as age, the presence of dependent children, household income, education and health. Men are less likely to engage in physical activity as they age, but women are more likely. This may be due to the fact that parenthood has a greater impact on the likelihood of women participating in regular physical activity: thus, as children grow-up and leave the home, women have more free time to dedicate to physical activity. No significant relationship with household income and physical activity was observed in men, but higher household income has a positive effect on the likelihood of women reporting regular physical activity. This may be due to the fact that women with higher income may be able to purchase time saving devices and have more time for leisure activities. No significant relationship between education and physical activity was observed for men but high education had a positive impact on the reported physical activity of women. This may be due to a major limitation of this study which is the inability to distinguish between leisure time physical activity and work based physical activity. Men with lower education may be concentrated in occupations demanding strenuous physical activity, but women's labour intensive occupations are less strenuous. Further research should use panel data to distinguish between different types of physical activity to eliminate this problem. Finally, both men and women in good health tend to report more physical activity but this effect is more pronounced in women.

Table 1: *Variable Labels and Definitions*

<u>**Variable Name**</u>	<u>**Description**</u>	<u>**HILDA Code**</u>
Dependent Variable		
activity	0-Physically Inactive < 3 days a wk	lspact
	1-Physically Active>=3 days a wk	
Explanatory Variables		
status	0-seperated/divorced/widowed	mrcurr
	1-legally married/cohabiting	
	2-never married/not defacto	
age	adults aged 18-65	hgage
agesqrd	age squared	hgage^2
preschoolkids	0-No children aged 0-4	tcr04
	1-Children aged 0-4	
d_region	0-NSW,ACT,VIC,QLD,SA,WA,TAS, NT	hhmsr
	1-Capital Cities	
d_remoteness	0-Remote,Very Remote, Outer Regional, Inner Regional	hhra
	1-Major City	
d_ft	0-unemployed	esbrd
	1-not in labourforce	
	2-employed pt	
	3-employed FT	
hourlywage	weekly gross wage divided by hours worked per week	wscei/jbhruc
householdincome	household financial year gross income/number of people in the household	hifefp/hhpers
occupation	0-Managerial/Profession/Associate Professional/Tradework	jbmocc2
	Advanced Services/Intermediate Services	
	Intermediate Production/Elementary Work	
	1-Labour Work	
ses_status	0-High Disadvantage (highest 3 deciles of social deprivation)	hhda10
	1-Medium Disadvantage (4 middle deciles of social depriviation)	
	2-Low Disadvantage (lowest three deciles of social deprivation)	
education*	0-No qualifications	
	1-Year 12 or undefined certificate	edhigh
	2-Certificate I, II, III, IV	
	3-Diploma/Advanced Diploma	
	4-BA or higher	
sf6d	Health state classification derived from the SF-36	ghsf6d
generalhealth	0-excellent/very good	gh1
	1-good/fair	
	2-poor	

* More information regarding the Australian educational system can be found at http://www.aqf.edu.au/aboutaqf.htm

Table 2: *Individual Characteristics Only* (** Indicates significant at 1% level * Indicates significance at 10% level. Standard Errors are in parenthesis.)

Dependent Variable	Explanatory Variables	MALES Eq. 1 [mfx α=0]	MALES Eq. 2 [mfx α=0]	MALES Eq. 3 [mfx]	FEMALES Eq. 1 [mfx α=0]	FEMALES Eq. 2 [mfx α=0]	FEMALES Eq. 3 [mfx]
Physical Activity Participation	Hourlywage	-0.0003 (0.003)	-0.0002 (0.0003)	-0.001 (0.001)	0.0001 (0.0004)	0.0002 (0.0002)	0.0002 (0.001)
	Household Income	0.0002 (0.0001)	0.0002 (0.0001)	0.00004 (0.002)	0.00001** (0.00001)	0.00001** (0.00001)	0.00003** (0.00001)
	Age	-0.02** (0.01)	-0.02** (0.01)	-0.06** (0.02)	0.001 (0.001)	0.006 (0.003)	0.02 (0.02)
	Age Squared	0.00003** (0.000001)	0.00001 (0.0001)	0.0001** (0.00002)	-0.0001 (0.0001)	-0.00004 (0.000003)	-0.0002 (0.00002)
	Employed Full Time	-0.06* (0.02)	-0.04 (0.03)	-0.15* (0.05)	-0.04* (0.02)	-0.02 (0.02)	-0.09* (0.04)
	Education						
	Year 12 or undefined certificate	0.02 (0.04)	0.09 (0.11)	0.04 (0.09)	-0.05 (0.03)	-0.01 (0.03)	-0.13 (0.08)
	Certificate I, II, III, IV	0.01 (0.03)	0.09 (0.09)	0.04 (0.07)	0.002 (0.03)	0.02 (0.03)	0.01 (0.08)
	Diploma/Advanced Diploma	-0.09 (0.04)	-0.07 (0.08)	-0.20 (0.10)	0.11* (0.04)	0.03 (0.06)	0.26* (0.09)
	BA or higher	-0.01 (0.03)	0.06 (0.10)	-0.01 (0.08)	0.03 (0.03)	0.05 (0.06)	0.07 (0.07)
	Labour Work	0.13** (0.03)	0.09** (0.04)	0.31** (0.07)	0.08* (0.03)	0.02* (0.02)	0.18* (0.08)
	Marital Status						
	Legally Married/Cohabiting	-0.11** (0.03)	-0.11** (0.05)	-0.27** (0.08)	0.04 (0.03)	0.005 (0.02)	0.09 (0.07)
	Not Married or Cohabiting	-0.04 (0.04)	-0.07 (0.05)	-0.10 (0.10)	0.12* (0.04)	0.04 (0.04)	0.27* (0.09)
	Children						
	zero to four	-0.08** (0.02)	-0.04** (0.02)	-0.18** (0.05)	-0.14** (0.02)	-0.07** (0.01)	-0.34** (0.06)
	five to fifteen	-0.01 (0.02)	-0.01 (0.03)	-0.02 (0.05)	-0.08** (0.02)	-0.04** (0.02)	-0.18* (0.05)
	fifteen plus	-0.03 (0.0.2)	-0.02 (0.03)	-0.07 (0.05)	-0.06 (0.02)	-0.02 (0.01)	-0.14 (0.05)
	Region						
	Capital City	-0.09** (0.02)	-0.02** (0.01)	-0.21** (0.05)	-0.08**(0.03)	-0.002**(0.03)	-0.17** (0.05)
	Relative socioeconomic statusof neighbourhood						
	Medium Disadvantage	0.03 (0.02)	0.004 (0.02)	0.05 (0.03)	0.04 (0.02)	0.001 (0.003)	0.08 (0.04)
	Low Disadvatnage	0.06* (0.02)	0.01 (0.02)	0.13* (0.06)	0.07* (0.02)	0.02 (0.004)	0.13* (0.06)
		n=14390	n=8876	n=14390	n=14020	n=8094	n=14020
	log likelihood	-8396.083	-3435.808	-8389.473	-8087.5645	-3119.0605	-8087.5645

Table 3: *Individual Characteristics and Health* (** Indicates significant at 1% level * Indicates significance at 10% level. Standard Errors are in parenthesis.)

Dependent Variable		**MALES** Column 1 [mfx α=0]	Column 2 [mfx α=0]	Column. 3 [mfx]	**FEMALES** Column 1 [mfx α=0]	Column 2 [mfx α=0]	Column. 3 [mfx]
Physical Activity Participation	Hourlywage	-0.0003 (0.003)	-0.0002 (0.0002)	-0.001 (0.001)	0.0002 (0.004)	0.0001 (0.004)	0.00004 (0.0001)
	Household Income	0.00001 (0.00001)	0.00003 (0.00001)	0.00004 (0.002)	0.00001** (0.00001)	0.00001* (0.00001)	0.00003** (0.00001)
	Age	-0.02* (0.01)	-0.004 (0.01)	-0.04* (0.02)	0.04 (0.03)	0.05 (0.06)	0.02 (0.02)
	Age Squared	0.0002* (0.0001)	0.0001 (0.0001)	0.001* (0.0002)	-0.003 (0.0003)	-0.0002 (0.0004)	-0.0002 (0.0002)
	Employed Full Time	-0.06* (0.02)	-0.04 (0.03)	-0.15* (0.05)	-0.04* (0.02)	-0.05 (0.02)	-0.11** (0.04)
	Education						
	Year 12 or undefined certificate	-0.01 (0.04)	0.09 (0.11)	-0.03 (0.09)	-0.07* (0.03)	0.06 (0.08)	-0.18* (0.08)
	Certificate I, II, III, IV	0.001 (0.03)	0.09 (0.09)	0.01 (0.07)	0.01 (0.03)	0.11 (0.06)	0.01 (0.08)
	Diploma/Advanced Diploma	-0.12* (0.04)	-0.07 (0.08)	-0.28* (0.09)	0.08* (0.04)	-0.03 (0.13)	0.20* (0.09)
	BA or higher	-0.05 (0.03)	0.06 (0.10)	-0.11 (0.08)	-0.01 (0.03)	0.02 (0.09)	-0.02 (0.07)
	Labour Work	0.12** (0.03)	0.07** (0.05)	0.29** (0.09)	0.10** (0.03)	0.06* (0.04)	0.23* (0.08)
	Marital Status						
	Legally Married/Cohabiting	-0.08* (0.03)	-0.06 (0.05)	-0.19* (0.08)	0.02 (0.03)	0.002 (0.05)	0.04 (0.07)
	Not Married or Cohabiting	-0.03 (0.04)	-0.04 (0.04)	-0.06 (0.09)	0.09* (0.04)	0.08* (0.06)	0.20* (0.09)
	Health						
	SF6D	0.75** (0.07)	0.46** (0.15)	1.75** (0.16)	1.01** (0.007)	0.06** (0.01)	2.38** (0.17)
	Children						
	zero to four	-0.08** (0.03)	-0.02** (0.02)	-0.17** (0.05)	-0.15** (0.02)	-0.15** (0.03)	-0.36** (0.06)
	five to fifteen	-0.01 (0.02)	-0.001 (0.02)	-0.03 (0.05)	-0.08** (0.02)	-0.10** (0.03)	-0.19** (0.05)
	fifteen plus	-0.03 (0.02)	-0.02 (0.02)	-0.07 (0.05)	-0.05 (0.02)	-0.04 (0.03)	-0.11 (0.05)
	Region						
	Capital City	-0.09** (0.02)	-0.02** (0.01)	-0.24** (0.05)	-0.08** (0.02)	-0.01** (0.003)	-0.19** (0.05)
	Relative socioeconomic status of neighbourhood						
	Medium Disadvantage	0.03 (0.02)	0.004 (0.02)	0.07 (0.05)	0.04 (0.02)	0.002 (0.003)	0.10 (0.05)
	Low Disadvantage	0.06* (0.02)	0.01 (0.02)	0.15* (0.06)	0.07* (0.02)	0.02 (0.004)	0.17* (0.06)
		n=14627	n=9066	n=14627	n=13786	n=7913	n=13786
	log likelihood	-8471.1416	-3497.2775	-8465.3027	-7852.4146	-3006.7501	-7842.0542

Table 4: *Endogeneity:* (** Indicates significant at 1% level * Indicates significance at 10% level. Standard Errors are in parenthesis.)

Explanatory Variables	MALES			FEMALES		
	Eq. 1 [mfx α=0]	Eq. 2 [mfx α=0]	Eq. 3 [mfx]	Eq. 1 [mfx α=0]	Eq. 2 [mfx α=0]	Eq. 3 [mfx]
Health				-		
Good/Fair	-019** (0.02)	-0.06** (0.07)	-0.46** (0.04)	-0.20** (0.01)	-0.14** (0.02)	-0.49** (0.04)
Poor	-0.27** (0.06)	-0.08** (0.01)	-0.68** (0.18)	-0.26** (0.05)	-0.21** (0.09)	-0.72** (0.02)
Lagged Health						
Good/Fair	-0.06** (0.02)	-0.01* (0.01)	-0.13** (0.04)	-0.07** (0.02)	-0.01** (0.02)	-0.17** (0.04)
Poor	-0.04 (0.08)	0.07 (0.09)	-0.08 (0.19)	-0.21** (0.06)	-0.15** (0.09)	-0.55** (0.02)
SF6D	0.72** (0.09)	0.17** (0.09)	1.71** (0.19)	0.97** (0.09)	0.09** (0.02)	2.34** (0.21)
lagged SF6D	0.34** (0.09)	0.05** (0.03)	0.80** (0.19)	0.42** (0.08)	0.03** (0.02)	0.99** (0.19)
Wage	-0.002 (0.0001)	-0.0001 (0.0005)	-0.001 (0.001)	0.002 (0.002)	0.00002 (0.00004)	0.001 (0.001)
Lagged Wage	-0.001 (0.0001)	-0.0001 (0.0005)	-0.0007 (0.0001)	0.003 (0.0002)	0.000002 (0.00004)	0.002 (0.001)
	n=11388	n=6207	n=11388	n=10831	n=5539	n=10831

Table 5: *Verbeek-Nijman test for attrition*

# of waves	Chi2(1)	0.92
respondent is present	P>Chi2>	0.3373
if respondent is	Chi2(1)	0.00
present in all wave	P>Chi2>	0.956
if respondent is	Chi2(1)	1.56
present in the next wave	P>Chi2>	0.2111

The null hypothesis of random non-response cannot be rejected for any of the three tests.

Appendix A: *Percent Participate in Regular Physical Activity by Survey*

% Participate in Regular PA By Survey	**MEN**	**WOMEN**
HILDA (2001-2006)	52.7	46.5
2000 National PA Survey	46.9	45.5
Western Australian Adults 2002	57.2	52.2
NSW Population Survey 1998,2002-2005	52.6	43.8
Physical Activity of Queensland Adults	49.1	41.1

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