# Household Responses to Individual Shocks: Disability and Labor Supply

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**Abstract**

How do people respond to idiosyncratic shocks? Using longitudinal data from the Canadian Survey of Labour and Income Dynamics we use variation in health status to develop and estimate a life cycle framework which rationalizes observed responses of individuals and couples to disability shocks. Two puzzling findings associated with disability onset motivate our work: (1) the almost complete absence of 'added worker' effects within households and, (2) the fact that single workers' labor supply responses to disability shocks are larger and more persistent than those of married workers. We argue that these facts are consistent with optimal life cycle behavior when we account for the interaction of two mechanisms: first, a dynamic human capital accumulation motive linking wages to labor supply; second, the ability of spouses to transfer time through home production. We provide evidence supporting the empirical relevance of both these mechanisms and show that dynamic labor supply decisions depend crucially on the interaction of the two. Our findings suggest that the persistence of measured wage shocks may be in part a by-product of optimal individual responses rather than an inherent feature of a random efficiency process.

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# 1 Introduction

Idiosyncratic risk is a pervasive, and much studied, feature of economic life.[1] In the incomplete markets literature idiosyncratic shocks are often modeled as persistent perturbations to the wage process. This approach simplifies the statistical analysis of income risk but it also presents some shortcomings: it restricts responses to different types of idiosyncratic risk—e.g., job risk, wage risk and health risk—to be identical, and it does not distinguish the direct effect of a shock from the effects due to agents' optimal responses. These limitations of the standard model become apparent when looking at optimal behavior of families. Shocks are often experienced at the individual level; yet responses to shocks are determined at the level of the household and have implications for all members of the family. Consequently, the effects of idiosyncratic shocks on individual outcomes are partly the result of joint decisions which may not be directly observed.

We use microdata information on disability onset to investigate the way in which individuals and couples handle shocks over their life cycle. We draw on existing literature on disability, which provides measures of the costs (in terms of income and loss of working time) experienced by households with a sick or disabled member.[2] Various studies document individual workers' responses to declining health or disability onset, with a focus on the incentives provided by disability insurance programs, as well as on optimal responses of spouses—so called 'added worker effects'.[3] We report comparable evidence on the consequences of disability for Canadian households using data beginning with the 1999 wave of the Survey of Labour and Income Dynamics. Our analysis highlights two interesting facts: much larger long-run negative responses to disability onset by prime-age single men, relative to married men; and negligible second-earner added worker effects. The latter finding

[1]See, to cite just a few, Abowd and Card (1989), Gottschalk et al. (1994) Attanasio and Davis (1996), Kocherlakota (1996), Blundell and Preston (1998), Attanasio and Rıos-Rull (2003), Ligon et al. (2002), Storesletten et al. (2004), and Meghir and Pistaferri (2006), Pistaferri et al. (2004), Guvenen (2007), Attanasio and Pavoni (2007), Heathcote et al. (2008), Krueger and Perri (2009) and Kaplan (2010).

[2]See, for example, Stephens (2001), Charles (2003) and Meyer and Mok (2008), using U.S. data.

[3]Analyses of U.S. data include Kreider (1999), Burkhauser et al. (2004) and Autor and Duggan (2003) and Low et al. (2009). For the Canadian experience see, among others, Gruber (2000). Recent work by Coyle (2004) on the 'added worker effect' following disability onset uses the HRS, while Charles (1999) uses the PSID. Stephens (2002) examines longitudinal evidence of added worker effects following job displacement of husbands.

confirms evidence from U.S. data on responses by female spouses of disabled workers.

These empirical findings are *not* consistent with a basic household decision problem with standard intertemporal labor supply choices, as surveyed in Blundell and MaCurdy (1999). A household model in which men are subject to partially unanticipated, persistent efficiency-reducing shocks predicts that married men should, on average, respond with larger reductions in labor supply than single men. This follows from the fact that the costs of negative shocks can be shared with the wife through reductions in spousal leisure (added worker effects), while income pooling provides insurance and mitigates wealth effects. Our analysis suggests that simply allowing for incomplete family commitment through endogenous divorce is not sufficient to explain the inconsistency between the data and the model's predictions. However a standard marriage model without commitment can go a long way towards explaining observed responses when two implicit restrictions are relaxed. First, we endogenize wage growth by allowing for dynamic learning-by-doing human capital accumulation. Second, we remove the restriction that intra-household transfers can occur only through income pooling, allowing also for optimal sharing of house-work and other types of non-labor, non-leisure ('*nll*') activities among spouses.

We show that the interaction of a dynamic human capital motive with optimal intra-household time allocation generates an effective mechanism for couples to handle disability shocks and, thereby, rationalizes much of observed responses of single men, married men and spouses of married men. Dynamic complementarities between human capital accumulation and labor supply produce an incentive for households to support a disabled member in maintaining his original level of labor supply, especially when disability shocks limit a person's ability to perform tasks in the home as well as in the market.[4] We show that intra-marital task sharing provides an effective mechanism through which this support can be provided. With endogenous home production, households allocate home duties optimally as the solution to an intratemporal wealth maximization problem, similar to the one discussed in Knowles (2007) and drawing on work pioneered by Gronau(1977).[5] A by-product of optimal

[4] We use a framework similar to that of Shaw (1989), Imai and Keane (2004), Olivetti (2006) or Michelacci and Pijoan-Mas (2007), in which labor supply decisions—including drops in labor supply due to disability onset—are dynamically linked to future wages.

[5] See also Rios-Rull (1993) and Chiappori (1997).

home production is the ability of spouses to 'care' for each other during periods of disability, through what are effectively intra-household transfers of time. The interaction of dynamic human capital motive and intra-household task sharing produces life cycle behavior consistent with significantly milder responses in married men's labor supply following a disability, and with the observed absence of added worker effect, as increases in wife's share of home production leave less time for her to work in the market. We also report microdata evidence in support of this mechanism, using the PSID.

The layout of the paper is as follows. In section 2 we introduce a basic life cycle model of marriage and divorce, denoted the 'workhorse' model, in which males are subject both to productivity and disability shocks. This model generates predictions—larger labor supply declines for married men following disability onset, as well as added worker effects—which are inconsistent with data. Section 3 reports the empirical evidence. Section 4 presents the two simple extensions which characterize our unrestricted, or 'extended', model: (i) a dynamic motive linking human capital accumulation and labor supply; (ii) intra-household insurance through task sharing in home production. We show analytically that these simple extensions can help explain the facts documented in section 3. Estimation and parametrization of the numerical model are also discussed. Section 5 presents simulation results, comparing the extended model (model E) to the workhorse model, and assessing the role of the dynamic human capital motive and intra-household transfers in shaping observed responses. Finally, we consider some model extensions and present additional data evidence supporting the empirical relevance of the intra-household time-sharing mechanism. Section 6 concludes.

# 2 A simple model and two puzzles

In this section we develop a simple dynamic household model with endogenous marriage and use it to derive predictions about intra-household allocations and responses to shocks—specifically disability shocks. In section 2.1 we set up the life cycle problem for male-headed households as they transition between the single and married state. In section 2.2 we examine predictions from this model when men are confronted with an explicit process of time-stealing disability and we show that this 'workhorse' model does a poor job of explaining dynamic responses of different types of households to the onset of a disability.

## 2.1 A simple life cycle model of marriage

Individuals start adulthood as singles and may marry and divorce over the life cycle, living by turns in one-person (single) or two-person (married) households. For parsimony, and in keeping with our empirical and numerical exercise, we focus the analysis on males.[6] The matching and separation process is fully endogenous; however, the main focus of this paper is on understanding the responses to shocks exhibited by agents of a *given* marital status, rather than on the broader issue of how marital status evolves in response to shocks.[7] At each point in the life cycle, a man is described by his age $j$ and a state vector $x$ indexing non-human wealth, productivity and health. At the start of each period, a single man meets a marriageable partner—that is, a person whom he both wishes to marry and who wishes to marry him—with probability $q$. We assume perfect assortative mating by age and education, but otherwise the partner is drawn from a known distribution of wealth and productivity, $X_f^S(j)$.[8] Household-level wealth $a_M$ at time of marriage is equal to the sum of both members' personal assets $a$ and $a_f$. Denoting the $x$-conditional expectation operator as $\mathbb{E}$, an age-$j$ single male has value function

$$V^S(j,x) = \max_{\{c,l,a'\}} \Big( u(c,l) + \beta \mathbb{E}\big[(1-q)V^S(j{+}1,x') + q \int_{X_f^M} V^M(j{+}1, x'_M(x_f,x')) dX_f^M | j,x\big]\Big) \quad (1)$$

where $\beta$ is a composite individual discount rate, $x$ ($x_f$) is the vector of a man's (matched female partner's) characteristics; $x_M$ indexes the characteristics of a married household (the

[6]Our focus on disabled males is not based on the assumption that genders are inherently different in their economic responses to disability. However, to preserve model tractability, we focus the analysis on shocks experienced by household main-earners. In most prime-age Canadian married households (75% of which are dual-earner) the husband is still the primary earner, a fact replicated in the model.

[7]We examine the importance of endogenous marriage for our results in section 5.2 and appendix B. In related work, we develop a richer model of marriage formation and dissolution, with an emphasis on spousal renegotiation and insurance over the life cycle, and we focus on the joint determination of marital status and health.

[8]Education subscripting is omitted throughout for notational clarity.

union of the individuals' productivity and health states, plus $a_M$). The 'primes' denote next-period values. $X_f^M = X_f^M(j+1, x')$ is the subset of single women within $X_f^S(j+1)$ such that, for any $x_f \in X_f^M$, a match results in marriage given $x'$. $V^M$ is the value of marriage conditional on a couple's $x_M$. For any possible match, a marriage occurs if and only if:

1. $V_f^M(j, x_M(x_f, x)) > V_f^S(j, x_f)$

2. $V^M(j, x_M(x_f, x)) > V^S(j, x)$

Therefore, $q = q(j, x, a') = q^* \frac{\sigma_{j+1}^S X_f^M(j+1, x')}{X_f^S(j+1)}$, where $q^*$ is a state-invariant probability that a man meets *any* woman, and $\sigma_{j+1}^S$ is the relative share of the age $j$+1 female population that is single.[9] The value function $V_f(j, x_f)$ is the female analogue of (1), with $q_f(j, x_f, a_f')$ similarly depending on a woman's current state vector, intertemporal choices, expected evolution of $x_f$ conditional on choices, and the distribution of single men. In choosing whether to marry a current match, men and women consider their future marriage prospects and the (stationary) distribution of matches in the population.

Next, we turn to married households. Members of a married household maximize a joint objective function $U$,

$$U(j, x_M, \lambda, \theta^f, \theta) = \max_{\{c_f, l_f, c, l, a'\}} \Big((1-\lambda)V^M + \lambda V_f^M\Big) \tag{2}$$

for a given 'marriage contract' $\lambda$, specifying the weight of each partner's individual value function in the joint maximization problem. The husband's (wife's) non-pecuniary value of marriage is given by $\theta$ ($\theta^f$) which enters utility additively in every period he (she) is married. A married man's individual value function is

$$\begin{aligned} V^M(j, x_M) = u(\mathbf{c}, \mathbf{l}, \theta) + \beta \mathbb{E}\Big[\varpi \max\big\{V^M\big(j+1, x_M'\big), V^S\big(j+1, x'(x_M')\big)\big\} \\ +(1-\varpi)V^S(j+1, x'(x_M'))|j, x_M\Big] \end{aligned} \tag{3}$$

where $\varpi = \varpi(j, x_M, a_M')$ and $(1-\varpi)$ is the probability that the marriage terminates without husband's consent. This could be due to wife's death, to an exogenous separation shock, or

[9] At age 19, $\sigma_j^S = 1$ since all individuals enter adulthood as singles. Thus, the probability of meeting a suitable partner $q$ changes over the life cycle with the share of the population that is single at each age.

to the wife no longer finding it optimal to be married given $x'_M$, that is, $V_f^S\big(j{+}1, x'_f(x'_M)\big) > V_f^M\big(j{+}1, x'_M\big)$. The husband may also independently opt to separate from his wife if next-period value of re-entering the marriage market is higher than the continuation value of the current marriage. His post-divorce state vector $x'(x_M)$ includes half the total assets of the married household. It's worth noting that in equation (3) there is no maximization: the individual basket of consumption and leisure ($\mathbf{c}$ and $\mathbf{l}$) and household savings $\mathbf{a}_M^{'}$ are the policy functions that solve the joint problem in (2).

To keep the joint allocation problem tractable we set $\lambda = .5$ so that marriages allocate utility in an egalitarian way. This assumption substantially simplifies the numerical implementation of the couples' problem and, in effect, makes it feasible to compare the quantitative implications of several alternative models. Nonetheless, the resulting intra-household allocation can be thought of as the outcome of bargaining between partners over a marriage contract $\lambda$ in the initial period of marriage.[10] In more sophisticated models of marriage, $\lambda$ conceivably evolves over time to prevent 'inefficient' divorces from occurring (see Mazzocco and Yamaguchi, 2007).

## 2.2 Disability in the workhorse model

Next, we focus on the solution of the intertemporal problems described above. We first explicitly define the personal state spaces $x$, $x_f$ and $x_{_M}$. Vector $x$ is given by $\{a, w, \delta_h, \delta_n\}$, $x_f$ by $\{a_f, w_f\}$, and $x_{_M}$ by $\{a_M, w_f, w, \delta_h, \delta_n\}$.[11] As before, $a$ denotes household-level assets and is a function of households' saving choices. $w$ is the current wage commanded in the

[10] The $\lambda$ in the initial period of marriage ($\lambda^*$) is the solution to the following cooperative (Nash) bargaining problem:

$$\begin{aligned}
&\lambda^* = \arg\max_{\lambda} S\left(j, x_f, x | \lambda, \theta^f, \theta\right) \\
&s.t. \\
&S(.) = \left[V^M(j, x_{_M}(x_f, x)|\lambda, \theta) - V^S(j, x)\right]\left[V_f^M(j, x_{_M}(x_f, x)|\lambda, \theta^f) - V_f^S(j, x_f)\right] \\
&V^M(j, x_{_M}(x_f, x)|\lambda, \theta) - V^S(j, x_{_M}(x_f, x)) \geq 0
\end{aligned}$$

where $S(\cdot)$ is the product of the partners' individual surplus from marrying, conditional on at least one partner's surplus (here, the male's) being positive.

[11] For numerical tractability, and for reasons discussed in footnote 6, only men are assumed to be subject to a random health process. Therefore $x_f$ contains only asset holdings and wage.

labor market, assumed to be independent of $\{\delta_h, \delta_n\}$, which index disability status. Both $w$ and $\{\delta_h, \delta_n\}$ evolve exogenously subject to separate processes for persistent shocks. The $\delta$'s are multiplicative factors which 'steal' time from individuals by increasing the total amount of time required to complete a given activity: 'labor limiting' ($\delta_n$) shocks increase the amount of time required to complete a unit of market work, while 'home-limiting' ($\delta_h$) shocks increase the time required to complete a unit of non-market, home-based *nll* activity.[12] At each point in the life cycle, a married couple solves (2) subject to constraint set

$$\begin{aligned}
&\xi_1 : \frac{(T - \delta_h \overline{h} - l)}{\delta_n} w + (T - \overline{h}_f - l_f) w_f + (1+r) a_M + b(\cdot) - c_f - c - a_M^{'} = 0 \\
&\xi_{2a} : l \leq T - \delta_h \overline{h} \qquad\qquad \xi_{2b} : l_f \leq T - \overline{h}_f \\
&\xi_{3a} : \varpi = \varpi(a'_M; \delta_h, \delta_n, w_f, w) \qquad\qquad \xi_{3b} : \varpi^f = \varpi^f(a'_M; \delta_h, \delta_n, w_f, w)
\end{aligned} \tag{4}$$

where $\xi_1$ is the shadow value of the household budget constraint, $\xi_2$ are the shadow values of the couple's time constraints, and $\xi_3$ captures the shadow value to each partner of the probability of avoiding a forced separation in the next period. The function $b(\cdot)$ captures all benefit entitlements. $T$ is a fixed weekly time endowment and $\overline{h}$ is the amount of time that must be devoted to *nll* activities, such as errands or work at home. Hours of market work are denoted $n$.[13] The problem is exactly identical for a single male household, with $a$ replacing $a_M$, $w_f = \lambda = \xi_{2b} = \xi_{3b} = 0$, and the multiplier $\xi_{3a}$ referring to $q = q(a'; \delta_h, \delta_n, w)$ and giving the shadow value of the likelihood of successfully matching as a function of expected next-period state variables.

After solving the constrained optimization problem at an interior solution for $l$,[14] the

[12]The notion of time-stealing disability is fairly common in the health literature: see Batavia and Beaulaurier (2001). An alternative approach from the economics literature is to model a stock of health (or 'energy') and let people make endogenous investments affecting its status, as in Becker (1985) and Becker (1991). Given unobservability of health stocks, this extension would substantially complicate estimation. At the same time we believe it would reinforce the proposed mechanism in the extended model with human capital accumulation and task sharing, without adding any crucial insight.

[13]We omit the constraint on borrowing, $a \geq \underline{a}$. In our numerical implementation we set $\underline{a}$ relatively low to allow for borrowing up to roughly 1.5 times average household income. The borrowing interest rate is estimated through model simulation and lies above the saving interest rate.

[14]The FOCs for husband and wife are, respectively, $(1-\lambda)u_l = \xi_1 \frac{w}{\delta_n}$ and $\lambda u_l^f = \xi_1 w_f$. In appendix B we derive similar expressions for the case in which $w$ depends on past labor supply.

following expressions give the uncompensated own-responses of hours worked to a $\delta_n$ shock ($\mu_{\delta_n}$) and a $\delta_h$ shock ($\mu_{\delta_h}$), as well as spousal responses to either type of shock ($\mu^f_\delta$):

$$\mu_{\delta_n} = \frac{1}{\delta_n^2}\left(\frac{u_l}{u_{ll}} - \frac{\partial \xi_1}{\partial \delta_n}\frac{w}{(1-\lambda)u_{ll}} - \delta_n n\right) \gtreqless 0 \tag{5}$$

$$\mu_{\delta_h} = \frac{1}{\delta_n^2}\left(-\frac{\partial \xi_1}{\partial \delta_h}\frac{w}{(1-\lambda)u_{ll}} - \delta_n \overline{h}\right) \gtreqless 0 \tag{6}$$

$$\mu^f_\delta = -\frac{\partial \xi_1}{\partial \delta}\frac{w_f}{\lambda u^f_{ll}} > 0 \tag{7}$$

The expression for $\mu_{\delta_n}$ in (5) decomposes into the usual intertemporal substitution (first term) and wealth (second term) effects. It differs from the response to a standard productivity shock because of a 'time-loss' effect which reflects the reduction in disposable time experienced by disabled individuals, as described in the second panel of figure 1.[15] By contrast, there is no substitution effect associated to home-limiting disability in (6): a $\delta_h$ shock reduces household resources and restricts the choice over time allocations, but does not affect relative prices of labor and leisure. Different disability shocks, however, affect the wife through an identical channel: $\mu^f_\delta$ summarizes a pure wealth effect that takes the same form for both types of shock.

Note that these expressions do not include any term capturing changes in own or spousal labor supply due to changes in $\xi_3$ and $\varpi$ ($q$ for singles) from a $\delta$ shock. The reason is that, given exogenous wage $w$, the only choice variable directly affecting $\varpi$ ($q$) is $a'$. If the couple chooses to change their saving behavior to reduce the likelihood or consequences of a split, labor supply may adjust to restore the intratemporal optimality condition, but this effect is of second order. Therefore, in the workhorse model, the effect of disability on labor supply

[15] To interpret the disability-augmented budget constraint, note that an increase in $\delta$ affects both household budget constraint ($\xi_1$) and husband's feasible time constraint ($\xi_{2a}$). Its effects are depicted in figure 1 for the case of a $\delta_n$ shock. For a given level of spousal leisure, a positive $\delta_n$ shock operates exactly like a negative wage shock, by rotating the household budget constraint inward along the x-axis in the right panel, and reducing the total amount of period income ($I$) that houshold can achieve. Unlike a wage shock, a $\delta_n$ shock has the additional effect of rotating inward the man's feasible time frontier between labor and leisure, along the x-axis in the right panel. The corresponding time-loss effect for a $\delta_h$ shock would be to shift the budget line inward, parallel to the original line. These time-loss effects are important, as they predict a drop in labor supply for all men following disability onset, even when, as is likely for both types of disability, optimal leisure decreases after the shock.

due to expected marital stability is relatively small, particularly for couples who do not change marital status from one period to the next (the focus of our analysis).

A major implication of the expressions in (5)-(7) is that disability onset has the strongest negative effect on labor supply immediately after a shock is realized, since substitution and time-loss effects are temporary, lasting only while $\delta > 1$; on the other hand, the potential change in $\xi_1$ (wealth effect) has positive effects on $n$ and $n_f$ that outlast the shock itself. Two more implications of these equations are worth discussing. The first follows immediately from (7): conditional on the husband's shock being at least partially unexpected and sufficiently large, we should observe an increase in wife's labor supply—an 'added worker effect'. The second, less obvious, implication is that, following a shock of similar magnitude, labor supply should drop more, on average, for married men than for single men, due to the insurance provided by marriage: not only do husband's potential earnings account for a smaller share of total household resources, but the consumption loss resulting from a similar drop in effective resources is shared among two people with concave preferences. This implication is further strengthened when considering that married households typically hold higher per-capita assets (i.e. non-human wealth) than single households; in our data, the median (financial) wealth-to-income ratio of married men at the peak of the life cycle is 70% larger than the corresponding ratio for single male households in the same age range.

In summary, comparative statics suggest that:

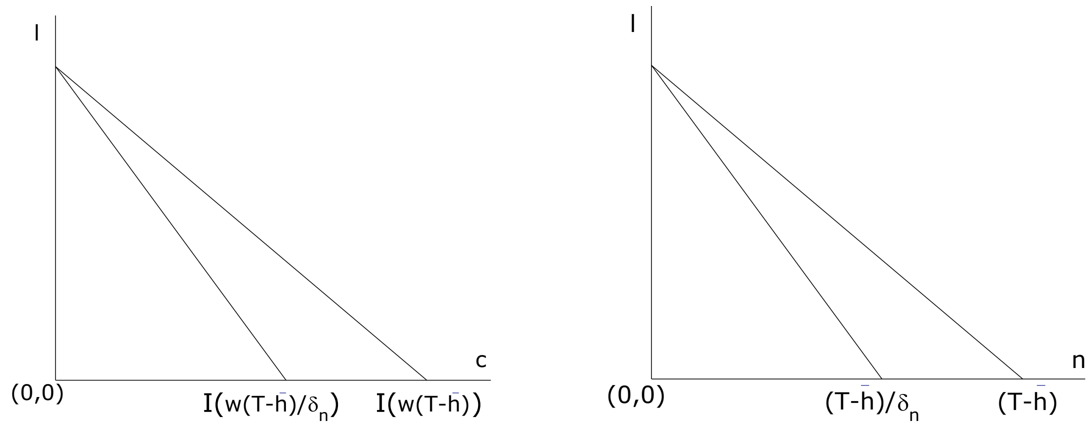
1. other things constant, married men should experience larger reductions in labor supply following disability onset;

2. an 'added worker effect' should be present, conditional on the shock being partly unexpected and large enough to change household's perception of permanent income.

In the next section, we show that these predictions are counterfactual.

Some caveats are in order. First, these predictions refer to married and single men's reactions to similar $\delta$ shocks. Our data evidence suggests that married and single men may face different processes for health risk. In fact, as suggested in section 5.2, these can arise endogenously through the marriage and separation process. Second, prime-age married couples and unattached individuals are likely to have, on average, different wages and benefit entitlements.[16] In the numerical analysis we account for both these issues and, in section 5, we show that they are insufficient to reverse the counterfactual predictions of the 'workhorse' model.[17]

Figure 1: Disability and household optimality constraints




(a) labor-limiting disability: HH budget

(b) labor-limiting disability: Feasible time use

# 3 Responses to disability: empirical evidence

The main data source for our study is the Canadian Survey of Labour and Income Dynamics (SLID), a longitudinal survey of Canadian Households maintained by Statistics Canada. The SLID follows a sample of about 8,500 households per wave, for a period of six years, with the majority of income data taken directly from tax records. A new wave begins every three years, so two waves are always active. We use the 1999-2004, 2002-2007 and the first three years of the 2005-2010 waves. Compared to other income panel studies, the SLID contains detailed information about the *economic* consequences and severity of disability, though, like most income studies, it provides little information on actual *physical* features of the

[16]In deriving our analytical expressions we brush aside the fact that benefits $b(.)$ may change with $\delta$.

[17]Another possible concern regards the exogeneity of health shocks. However, there isn't much evidence of direct effects of income on health (for a discussion see Cutler et al. (2006)). Using HRS data, Smith (2005) shows instead that, among otherwise similar people, those suffering health events drop out of the labor force more frequently and work fewer hours, resulting in long-term earnings' losses.

limitation. Our measures of disability are constructed from responses to a series of questions in the SLID disability module.[18] We classify disability into three broad types. Disability is 'latent' if it limits physical activity but does not directly limit capacity at work, school, home or other activities such as transportation or leisure. Disability is 'work-limiting' if it limits the respondent at work or in other work- or human capital-based activities such as school or job-search. Finally, disability is 'home-limiting' if the individual reports being limited in home-based or other non-work activities such as transportation or leisure. Table 1 reports incidence of disability by type in 2007 for men aged 20-45 and 46-69 (the ages for which all types of limitation are reported).[19] More than half of all reported disabilities are both work- and home-limiting, while relatively few are exclusively work-limiting. Moreover, the incidence of all types of disability is high and increases with age. Around 32% of working-age respondents over age 45 report at least some dimension of disability.

Table 1: Incidence of reported disability by type in 2007

| age | no disability | latent | $h$-limiting | $n$-limiting | $h$ and $n$-limiting |
|---|---|---|---|---|---|
| 20-45 | 84.0% | 3.2% | 2.6% | 1.5% | 8.7% |
| 46-69 | 68.0% | 6.2% | 6.7% | 1.7% | 17.4% |

## 3.1 Measuring responses to disability onset

Our approach is similar to that of Meyer and Mok (2008), who in turn build on work by Charles (2003) and Stephens (2001). We focus on results from two basic estimating equations:

$$y_{it} = \alpha_i + \pi_t + \mathcal{F}(age_i) + \pi_X X_{it} + \sum_k \dot{\delta}_k A_{kit} + e_{it} \tag{8}$$

$$y_{it} = \alpha_i + \pi_t + \mathcal{F}(age_i, \eta_i) + \pi_X X_{it} + \sum_k \tilde{\delta}_k A_{kit} + \sum_k \overline{\delta}_k A_{kit}\eta_{it} + e_{it} \tag{9}$$

[18]Disability is self-reported.'Justification' bias, where individuals with lower incomes or worse job prospects report more disability, is a problem with all subjective measures. Studies by Au et al. (2005) (for subjective health measures) and Campolieti (2002) (using Canadian data from the National Population Health Survey) find that justification bias is small enough to be of less concern than measurement error or attenuation bias. Similar evidence for the U.S. is discussed in Low and Pistaferri (2009).

[19]Incidence statistics are weighted using cross-sectional weights provided by Statistics Canada.

The $y_{it}$ dependent variable can be labor supply (hours and participation) or wages. Equation (8) can be estimated for separate or pooled samples of married men and single men, as well as for spouses of married men, while equation (9) can only be estimated from pooled samples of married and single men. $X$ contains demographic and life cycle information including education, household size, number of children, a dummy for living in a city of at least 50,000, provincial minimum wage, a measure of self-assessed health, regional and panel dummies.[20] Time effects, $\pi_t$, are captured with year dummies. To control for individual or family fixed effects $\alpha_i$, we include time averages of all covariates in $X$ for each individual over the observed years. The marital status index $\eta$ is equal to 1 for married and 0 for non-married. We limit the sample to individuals for whom $\eta$ is unchanged over the years of observation. $\mathcal{F}(age)$ is a cubic function, with each term also interacted with $\eta$ in (9). Index $k$, ranging from -1 to +10, denotes the number of years elapsed from initial disability onset (observations prior to one year from onset are the control group), and $A$ is an indicator variable indexing $k$. The $\dot{\delta}_k$ (estimated separately for married men, single men and spouses of married men) and $\overline{\delta}_k$ (estimated from a pooled sample of men) are plotted in section 3.1 for labor supply and section 3.2 for wages.[21]

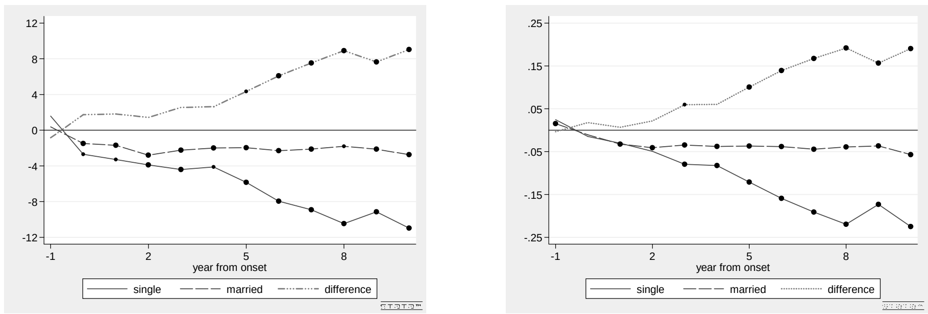
**Labor supply responses to disability.** Figures 2 and 3 report mean changes in labor supply, estimated from equation (8), following disability onset for married (including common law) and unmarried (never-married, separated/divorced and widowed) men, and for spouses of married men. The left panel reports changes in total annual hours worked, divided by 50 to give an average weekly level. The right panel shows changes in participation rates: the probability that the disabled individual worked at least one hour per week on average during the previous year. In each figure, large dots denote estimates which are significant at the 5% level, whereas small dots indicate significance at the 10% level. The grey dashed lines in

[20] In robustness regressions we ran specification 8 for married men with and without children and found no systematic differences in estimated responses.

[21] Due to the six-year panel dimension of the SLID, we rely on individuals' reports of the duration of their current disabling condition—the number of years they had the condition before reporting it—to identify individuals at long durations from onset. This can potentially lead to selection bias, so we re-weight data to create a sample that approximates as closely as possible the post-onset population of Canadian men based on information in the National Health and Population Survey (NPHS). More information on variables and sample adjustments are provided in appendix A.

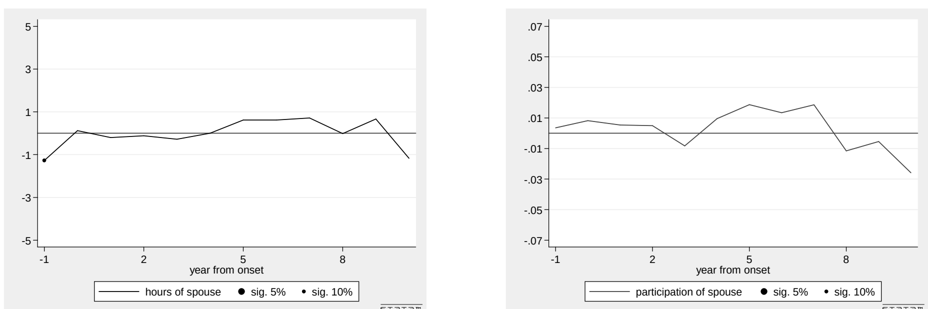
Figure 2 plot *differences*, estimated from equation (9), between post-onset changes in labor supplies of married and single men.

Figure 2: Male labor supply following disability onset by marital status




(a) Total hours (b) Participation

Figure 3: Spousal labor supply following disability onset shocks

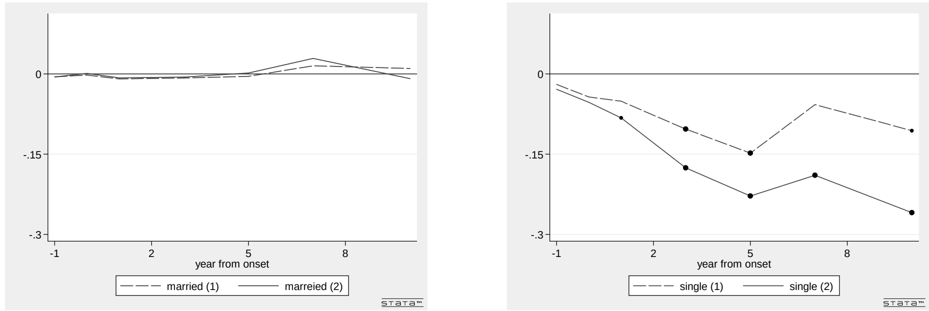



(a) Total hours (b) Participation

The figures show that total hours and participation effects of disability are persistent. On average neither married nor single men return to their pre-onset level of work. Two other patterns are visible. First, single men exhibit larger and more persistent drops in labor supply than their married counterparts. Five years post-onset the drop in average weekly hours is twice as large for singles as for marrieds; at ten years post-onset it is around three times as large. Second, we do not observe any meaningful added worker effect for wives of disabled men. The finding of negligible added worker effects is consistent with U.S. findings by Coyle (2004) using the HRS and Charles (1999) using the PSID.[22]

[22] However Stephens (2002) reports PSID evidence that long-run added worker effects after job displacement are significant, eventually replacing 25% of husband's lost annual income.

Figure 4: Male *log* wages following disability onset




(a) Married men (b) Single men

## 3.2 Disability onset and wages

Next, we examine the effects of disability onset on the mean log of hourly wage, disaggregated by marital status. For this exercise, we use a two-stage version of (8) which allows us to control for selection into the labor market. At the second stage we regress the log of composite hourly wage, reported in all jobs in the reference year, on a cubic in labor market experience, education, provincial minimum wage, indicator variables for urban status, regional status, year and SLID wave, plus time averages for all demographic controls, and the inverse mills ratio. At the first stage we include all these regressors plus a cubic in age, number of children and household size—variables we expect to have no *direct* effect on wages.

Figure 4 plots results. Married men do not experience significant declines in post-onset wages, even after controlling for selection into the labor force. For single men, however, the decline in wages over the post-onset period is large and mostly significant. Given sensitivity to sample selection, we report two sets of results: the first from the whole sample, (1), and the second from a sample of individuals who are observed for at least four years, (2). In both samples we pool individuals into two-year post-onset intervals to increase the precision of the estimator. The estimated long-run drop for single men reaches 12% in the full sample and 25% in the restricted sample. These large wage declines for singles are consistent with the hypothesis that wages move endogenously with hours worked.

# 4 Explaining the evidence: a dynamic household model

In this section we relax two implicit assumptions of the workhorse model and investigate some possible explanations for the discrepancy between theory and data documented in the previous sections. First, we link the wage process to past labor supply through a dynamic human capital mechanism which gives individuals some control over future earnings. Second, we allow for a richer set of intra-household transfers through home production in the form of task sharing within couples. We show analytically that these simple extensions have the potential to reverse the counterfactual implications of the workhorse model; we then develop and estimate a numerical counterpart of the model to quantify their effects.

## 4.1 Disability with human capital accumulation

The persistent drops in labor supply, and concurrent wage drops, for single men suggest a possible role for a dynamic human capital mechanism. We follow a series of authors (in particular Shaw 1989, Olivetti, 2006, Imai and Keane 2004 and Michelacci and Pijoan-Mas 2007) and introduce a 'learning by doing' human capital process by which current wage depends on previously accumulated human capital as well as previous period labor supply. With endogenous wages, the married household's problem (4) is augmented by an additional set of constraints:

$$\xi_{4a} : \mathbb{E}w' = H(l|w, \overline{h}, \delta_h, \delta_n) \qquad \xi_{4b} : \mathbb{E}w'_f = H^f(l_f|w_f, \overline{h}_f) \tag{10}$$

where $\mathbb{E}w' = H(l|\cdot)$ denotes next-period expected wage as a function of current labor supply, conditional on relevant states. As before, the constraint set for single men is identical to that of married men, with all $f$-indexed variables, as well as $\lambda$, $\xi_{2b}$, $\xi_{3b}$ and $\xi_{4b}$, set to zero; moreover, $a$ replaces $a_M$, and $\xi_{3a}$ now refers to the shadow value of $q$.

In appendix B we report and interpret the first order conditions and comparative statics for labor supply within the model augmented with human capital accumulation. Introducing human capital has a theoretically ambiguous effect. On the one hand, $\xi_3$ now enters the comparative statics for labor directly since the wage losses associated with changes in $n$ may lower $\varpi$ and/or $q$. This, along with the resource costs associated to wage loss, gives men who value marriage a stronger incentive to maintain their labor supply in the face of (potentially) temporary shocks. However, it may also induce a selection effect by which severely disabled, and consequently wage-poor, men are more likely to remain single or change marital status.

For single men, therefore, the dynamic human capital motive clearly improves the predictions of the model. For married men, however, there is a second factor at work: the human capital mechanism also makes it easier for wives to transition into main earner status by increasing their labor supply—and wages—over time, relieving chronically disabled husbands of the need to work. The results we report in section 5 suggest both these forces—selection and substitution within stable marriages—are indeed at work in the model.

## 4.2 Home production and intra-household time allocations

The second extension to the workhorse model allows for optimal time management within couples through task sharing. Analytically this amounts to an intratemporal wealth maximization problem in which spouses choose how to optimally allocate home-production duties, as in Knowles (2007). In the presence of home-limiting disability, this flexibility allows a healthy spouse to alleviate the time loss experienced by a disabled partner, raising both his utility and his potential for market work.

In all the models individuals must complete a set of 'non-labor, non-leisure' (*nll*) activities before labor and leisure decisions can be made. The time requirement for such activities was defined in section 2.1 as $\overline{h}$ for men and $\overline{h}_f$ for women. We now define the time a man (or woman) *actually devotes* to *nll* tasks as $h$ (or $h_f$).

With both task sharing and endogenous wages, the couple's full problem is a maximization of (2) with respect to $\{c_f, c, l_f, l, h_f, h, a'_M\}$, subject to

$$
\begin{aligned}
&\xi_1 : (T - l - \delta_h h)\frac{w}{\delta_n} + (1+r)a_M + b(\cdot) + (T - l_f - h_f)w_f - c_f - c - a'_M = 0 \\
&\xi_{2a} : l \leq T - \delta_h h \qquad\qquad\qquad\quad \xi_{2b} : l_f \leq T - h_f \\
&\xi_{3a} : \varpi = \varpi(a'_M, w'_f, w'; \delta_h, \delta_n) \qquad \xi_{3b} : \varpi^f = \varpi^f(a'_M, w'_f, w'; \delta_h, \delta_n) \\
&\xi_{4a} : \mathbb{E}w^{'} = H(l, h|w, \delta_h, \delta_n) \qquad\quad \xi_{4b} : \mathbb{E}w_f^{'} = H^f(l_f, h_f|w_f) \\
&\xi_5 : G(\overline{h}_f, \overline{h}) = \phi_f(h_f) + \phi(h)
\end{aligned} \tag{11}
$$

where $G(\cdot)$ defines the couple's aggregate *nll* obligations as a function of the partners' autarkic *nll* requirements. The FOCs for leisure are unchanged from those given in appendix B. The additional FOC for the intra-household *nll* allocation choice is

$$
\frac{\xi_1(\frac{\delta_h w}{\delta_n}) - \xi_{4a}\frac{\partial H}{\partial h}}{\xi_1 w_f - \xi_{4b}\frac{\partial H^f}{\partial h_f}} = \frac{\phi'(h)}{\phi'_f(h_f)} \tag{12}
$$

which simply equates the ratio of the partners' marginal human capital costs of $h$ to the ratio of their marginal *nll* productivities. Assuming incomplete specialization, so that both spouses engage in some market and some house work, the FOC implies that couples choose housework time inputs $h$ to maximize the value of their pooled disposable time. In a second stage, they optimally allocate this human wealth between leisure and saving/consumption/human capital investment according to the remaining FOCs from (11).

What does this imply for optimal labor supply responses to a husband's disability onset? Within stable marriages, the responses are now complicated by changes in the respective shares of *nll* tasks. Disability shocks make the husband less productive both in the labor market and at home. If the latter effect is dominant (an empirical question, addressed through model estimation), it will induce the wife to take over more *nll* tasks, thereby reducing the amount of time she can devote to market activities. There is also a second effect operating through the dynamic human capital motive and applicable to both $\delta_h$ and $\delta_n$ shocks: if the husband is initially the higher-wage earner, the couple may be inclined to temporarily allocate more of the *nll* burden to the wife in order to support the husband's labor supply, which in turn preserves his wages and, potentially, the stability of the union.

## 4.3 The numerical counterpart of the model

The interaction of dynamic human capital incentives and optimal households' transfers delivers a mechanism with the potential to rationalize observed responses to disability shocks. To inspect this mechanism, and verify its empirical relevance, we first develop a numerical counterpart of the model, then validate its performance in various ways.

The simulated economy is populated by one-member (single) and two-member (married) households who solve the period-by-period optimization problem described in section 2. The model is identical, except that the individual state space for males is $x = \{a, w, ds, rsk\}$ where $ds$ is a discrete set of combinations of $\{\delta_h, \delta_n\}$ and $rsk$ is an additional state variable capturing the risk of becoming and remaining disabled, discussed in more detail below. Given the large number of parameters needed for a numerical implementation, we proceed in two steps. First, a number of parameters are estimated directly from microdata. These estimates are then employed to numerically simulate the model and estimate the remaining parameters through simulated method of moments (SMM). We use a downhill simplex method to minimize the sum of squared percentage deviations between simulated and empirical targets.

**Demographics, marital evolution and preferences.** A model period is one year. Individuals enter the model at age 19, work to the age of 65 and live to a maximum age of 99. Education, discretized to be either high or low, is exogenously assigned. Each individual starts life as single and may be randomly matched with a person of same age and education while still single. The matching function is exactly as described in section 2.1, with two additional restrictions: (1) an individual is only matched with partners whose non-human wealth is at least one quarter and not more than four times their own;[23] (2) once married, couples face an exogenous divorce probability of .005 per period, which allows for half of all separations to be determined by unobservable non-economic factors rather than as endogenous responses to shocks.

Effective discount rates are age-varying, the product of an invariant gender-specific geometric discounting factor $\{\mathcal{B}_f, \mathcal{B}\}$ and age/gender-specific survival probabilities taken from

[23] For those in debt or with very low assets, matches occur only with partners whose wealth levels differ by less than approximately the mean household income in the model. This matching restriction substantially reduces the computational burden without significantly altering the distribution of successful matches.

Canadian vital statistics. Households save at real interest rate $r = 3.8\%$. Households age 65 and younger can also borrow at an interest rate of $r_B$ which is estimated in the model.

Individual period utility functions are given by

$$u^f = (1-\gamma_j^f)\frac{(c_f\tilde{n}_\eta)^{1-\omega}}{1-\omega} + \gamma_j^f \frac{l^{1-\psi}}{1-\psi} + I_\eta \theta^f$$

$$u = (1-\gamma_j)\frac{(c\tilde{n}_\eta)^{1-\omega}}{1-\omega} + \gamma_j \frac{l^{1-\psi}}{1-\psi} + I_\eta \theta \tag{13}$$

for women and men respectively, where $\omega$ and $\psi$ govern the intertemporal elasticity of consumption and labor, respectively; $\tilde{n}$ captures changes in marginal utility of consumption due to economies of scale in marriage; and $I_\eta$ is an indicator function for being married. We set $\omega = \psi = 1.5$, which results in men's Frisch elasticities broadly consistent with empirical evidence.[24] For couples $\tilde{n}$ is set to .85, following the OECD equivalence scale. The remaining parameters are estimated through SMM as described in section 4.4. The relative preferences for leisure, $\{\gamma^f, \gamma\}$, follow separate cubics in age for men and women. Age-varying $\gamma$ captures changing consumption needs due to deterministic fertility,[25] and allows us to generate reasonable life cycle profiles of hours worked in the presence of endogenous human capital.

**Home production and nll.** Individual *nll* time requirements ($\overline{h}$) are estimated from the public use 2005 Canadian General Social Survey (GSS), which provides time diary data for a representative cross-section of Canadians using a methodology similar to the American Time Use Survey. Our set of *nll* activities is very close to those activities, other than market work, excluded from 'Leisure Measure 2' in Aguiar and Hurst (2007)[26] and includes

[24] In the workhorse model the analytical Frisch elasticity is given by $\frac{1}{\psi}\frac{l}{\delta_n n}$. For a 40-year-old healthy married male working 45 hours per week, this corresponds to a Frisch elasticity of labor of around .83. Various authors, e.g. Rogerson et al. (2000), Domeij and Floden (2005) and Chang and Kim (2006), have shown that conventional estimation methods may underestimate the Frisch elasticity by 50% or more. Our findings confirm this problem: using Altonji (1986)'s method of estimating $\psi$ from the intratemporal optimality condition for married men results in an *estimated* Frisch elasticity of only .27, and uncompensated labor supply elasticity of .16 in the workhorse model. In model E, the analytical Frisch elasticity is more complicated, depending on $\psi$, $\delta_n$ and other variables. However, the same estimation procedure leads to an estimate of .14 (and an uncompensated elasticity of .10), both within the range suggested in the micro empirical literature on intertemporal labor supply. The estimated Frisch elasticity for married women is much larger (.60 in model E), which is intuitively appealing, although there is less of a consensus on its 'true' value in the literature.

[25] All women in the model, whether married or single, have children, which also impose time costs.

[26] The main difference is that we include personal care, pet care and gardening/grounds maintenance in

all traditional home production activities, yard and vehicle maintenance, procurement of services, and child care other than play. In the models, we allow *nll* requirements to evolve separately for high- and low-educated men and women by age and the presence of children. Table 2 reports means and standard deviations of weekly *nll* hours of prime-age individuals by gender and marital status.[27] Both women and men spend substantially more time on *nll* tasks when married than when single.

Table 2: Time devoted to *nll* task by gender and marital status: GSS

| Men | | Women | |
|---|---|---|---|
| Married | Single | Married | Single |
| 26.1 | 21.1 | 39.5 | 32.1 |
| (19.5) | (17.6) | (20.6) | (21.8) |

To identify and estimate the intra-household task sharing technology, we introduce the following restrictions on *nll* obligations and sharing technology:

$$\begin{aligned} \phi(h) &= \underline{h} + a\tilde{h}^{q} \\ \phi_f(h_f) &= \underline{h}_f + a_f\tilde{h}_f^{q_f} \\ G(\overline{h}_f, \overline{h}) &= \overline{h}_f + \overline{h} \end{aligned} \tag{14}$$

where $h = (\underline{h} + \tilde{h})$, and $\tilde{h}$ ($\tilde{h}^f$) are the husband's (wife's) time input into the 'allocatable' component of household *nll* obligations. The parameters $\{\underline{h}_f \leq h^f, \underline{h} \leq h\}$ denote the amounts of the household *nll* burden which cannot be shared and must be completed by each member using the same linear technology available to singles. Both $\underline{h}$ and $\underline{h}_f$ are estimated, as a proportion of total household per-period *nll*, as part of our SMM procedure. The last line of (14) states that a married household's total *nll* obligations are simply the

our definition of *nll*, while Aguiar and Hurst (2007) include them in their Leisure Measure 2 (LM2). We do not put education in *nll*, but we do adjust the total time endowments by gender, age, and education to account for time lost to study early in the life cycle. Finally, Aguiar and Hurst include sleep in LM2, while we exogenize a 'core' amount of sleep (42 hours) and consider the remainder to be leisure. Thus, individuals in the model divide 126 hours weekly between $n$, $l$, $h$ and education.

[27]The GSS reports data from diary days which can be summed within cells to give the mean weekly *nll*. However, the standard deviations reported at the weekly level are of limited value. We therefore report them only for illustrative purposes and omit them as moments in the SMM estimation of the model.

combined autarkic *nll* obligations of both partners.[28]

One can estimate task-sharing functions $\{\phi_f, \phi\}$ using: (i) the predicted combined sharable *nll* time of observationally similar singles as a dependent variable and, (ii), observed $\tilde{h}$ time inputs of married couples as right-hand side independent variables. We are not aware of any Canadian data providing information about *nll* activities for more than one household member. Therefore we estimate the following empirical counterpart using data on 'housework' from the 1999-2005 biannual waves of the Panel Study of Income Dynamics:

$$\overline{\mathtt{h}}_f + \overline{\mathtt{h}} = a_f \mathtt{h}_f^{q_f} + a\mathtt{h}^{q} \tag{15}$$

where $\overline{\mathtt{h}}$ and $\mathtt{h}$ are the empirical counterparts of the (allocatable) housework component of $\overline{h}$ and $h$ respectively. Non-linear estimates of (15) are reported in table 3, along with robust standard errors. Our estimates suggest that men's and women's time are relatively good substitutes in household production, with women becoming relatively more efficient than men at high levels of housework, around fifteen hours per week. Estimation details are in appendix C.1.

Table 3: Estimated task sharing technology for married couples

| | | | |
|---|---|---|---|
| $a_f$ | 1.494 | $q_f$ | 0.776 |
| | (0.285) | | (0.026) |
| $a$ | 1.569 | $q$ | 0.741 |
| | (0.517) | | (0.051) |
| | $n = 10,172$ | | $r^2 = .969$ |

**Disability process.** The process of disability is summarized by two state variables: $ds$, which indexes current disability status, and $rsk$, which captures a man's underlying risk of becoming, or remaining, disabled. We include $rsk$ to capture the idea that, while disability shocks arrive as 'news', men differ observably in their *susceptibility* to $ds$ shocks at each given age.[29] The $rsk$ matrix has three states. $rsk$ 1 and 2 denote high and low disability risk; men move randomly from $rsk$ state 1 into 2 as they age.[30] A third $rsk$ state captures

[28]Note that this is a special case of the set of constant-proportion parameterizations $G(\overline{h}_f, \overline{h}) = b(\overline{h}_f + \overline{h})$, with $b = 1$. If we did not restrict $b$, we could estimate $a$ and $a_f$ up to a multiplicative constant.

[29]Stephens (2001) argues that paths of consumption growth among disabled households are consistent with the idea that disability shocks may be partially anticipated, particularly by older workers.

[30]To estimate the process for $rsk$, we run a probit regression on SLID data in which the dependent variable

'chronic' disability, in which a limiting $ds$ state becomes permanent.

The $ds$ vector comprises six states in ascending order of severity: healthy ($ds$ 1); latent disability ($ds$ 2); $h$-limiting only ($ds$ 3); $n$-limiting only ($ds$ 4); $h$- and $n$-limiting, both milder ($ds$ 5), and severe ($ds$ 6). For non-chronic disabled men, transitions across $ds$ states follow an age- and $rsk$-specific Markov transition matrix estimated directly from the SLID. The probability that any limiting disability becomes chronic ($rsk$ 3) is 3.7% per period, chosen to match the observed chronicity of disability across six-year intervals in the data.

**Wage dynamics and human capital accumulation.** The workhorse model posits an exogenous wage process: we estimate a wage equation with controls for age, cohort, education, presence of a limiting disability, and other factors, and employ the two-stage estimator proposed by Wooldridge (1995) to control for the combination of selection into the labor market and fixed effects. The residual is assumed to follow an AR(1) process with autocorrelation coefficients $\{\rho^f, \rho\}$, for women and men respectively, and associated idiosyncratic perturbations distributed as $\{N(0, \sigma_\rho^{f^2})\ ,\ N(0, \sigma_\rho^2)\}$. We also allow for an additional white noise disturbance with distributions $\{N(0, \sigma_\nu^{f^2})\ ,\ N(0, \sigma_\nu^2)\}$. The latter we treat as measurement error and exclude from the model. We estimate $\rho^f = .957$, $\sigma_\rho^{f^2} = .0146$ for women and $\rho = .939$, $\sigma_\rho^2 = .0194$ for men. We also find a direct effect of disability and chronic disability on wages, and we control for these direct effects in the simulations. Since the estimated coefficients on age and education are correlated with other demographic controls, we estimate them as reduced form parameters in our SMM procedure.

In our human-capital-augmented models, we posit the following human capital process:

$$
\begin{aligned}
H_{i,t+1} &= H(n_{i,t} | H_{i,t}, ed_i, age_{t+1}, X_{i,t+1}, \nu_{i,t+1}) \\
&= \kappa_{it} + (\alpha_1 + \alpha_2 n_{i,t} + \alpha_3 n_{i,t}^2) H_t + \nu_{i,t+1} \\
w_t &= R_t H_t
\end{aligned}
\tag{16}
$$

is an indicator for having a disability during the course of the panel and the regressors include a variety of standard demographic controls, including age terms and self-assessed health. We then split predicted probabilities at the median so that half of the male SLID population is 'high' $rsk$ and half 'low' $rsk$, and these groups are used to estimate the high- and low-risk $ds$ matrices described above. The age-dependent probabilities of transitioning into $rsk$ 2 from $rsk$ 1 are chosen to replicate the shares of men in $rsk$ 1 and 2 at ages 20-25, 40-45 and 60-65. By age 66, more than 99% of men have transitioned into $rsk$ 2 and about 5% are chronically disabled.

where $R$ is the wage rate per unit of human capital, $n$ is average weekly hours worked in the previous year, $X$ is a vector of other observable covariates (including $\delta_n$) and $H$ is start-of-period human capital stock. The individual- and age-specific intercept $\kappa = \{\kappa_0 + \kappa_1 \times ed + \kappa_2 \times age + \kappa_3 \times age^2\}$ approximates the minimum human capital level a person can have, given age and education. Again, the $\kappa$'s are estimated in reduced form as part of our SMM procedure for model E. The rate of depreciation of $H$ is given by $(1 - \alpha_1)$ where $\alpha_1 = \alpha_{11} + \alpha_{12} \times ed$ varies across individuals by education level. $\alpha_k = \{\alpha_{k1} \times age + \alpha_{k2} \times age^2\}$, for $k = 2, 3$, governs the rate at which $H$ is replenished through market activity. The i.i.d. shock $\nu$ is heteroskedastic in age and current human capital stock. Since individuals may be able to predict and react to upcoming realizations of $\nu$, we instrument for the terms involving lagged hours with three-year lags of each age-hours interaction term. We also control for selection in a first stage regression using specific demographic indicators as restrictions. Following Imai and Keane (2004), we let $R_t = R = 1$ for all years in our sample. In the human capital model, we find no evidence of direct effects of disability on skill depreciation. Estimates of (16) for men and women are reported in appendix C.2, table 13, along with further details of the estimation procedure.

**Policy environment.** Government policy in the model approximates the existing patchwork of Canadian federal and provincial disability, retirement and anti-poverty programs. Table 4 reports all transfers in the model and whether they are assigned or estimated through model simulation. In every period, working-age households receive a basic transfer capturing unemployment benefits, child benefits, transfers from family members outside the household and other residual public and private transfers. These are targeted for single and married households as part of the SMM model estimation described in the next section. Low-income households with assets below a cut-off level receive a minimum-income benefit equal to basic welfare transfers available under Ontario Social Assistance. Non-workers over 60 receive a benefit worth 25% of expected weekly earnings based on the wage at age 60, up to the average weekly manufacturing wage of $22/hour. At 65 all individuals receive a flat-rate transfer equal to the federal Old Age Security (OAS) benefit, and low-income households receive an additional (non-asset-tested) benefit representing the Guaranteed Income Supplement (GIS).

Disability entitlements of working-age men depend on chronicity and type of disability. Men with non-chronic work-limiting disabilities receive a benefit approximately equal to one eighth of 75% of their current expected earnings if they reduce their work time by at least five hours per week below their healthy weekly average. This benefit approximates a temporary workers' compensation (WC) benefit, with average duration of about two months in Canada and available to roughly 80% of workers. Alternatively, any work-limited man can drop out of the labor force and receive a benefit proportional to his wage (up to $22 per hour) in the last period worked. This benefit could capture disability insurance payments from Canadian Pension Program, permanent WC benefits and/or private insurance. We estimate replacement rates for men in, respectively, $ds$ 4 or 5 and $ds$ 6, to match the average transfers received by prime-age single men with different severity of labor limitation in the SLID. Finally, many Canadian workers receiving temporary WC benefits (including workers in Ontario at establishments with more than twenty workers) are legally entitled to be rehired by their previous employer at a comparable wage once the disability has passed. Campolieti and Krashinsky (2006) show that workers who return to their previous jobs after suffering a workplace injury suffer negligible wage losses compared to workers who change employers. We capture this fact by allowing disabled workers who would otherwise be full time (at least 35 hours per week) and who reduce their labor supply by less than 20% in the current year to receive a human capital return equivalent to their full time hours.[31]

[31] To fund retirement and disability benefits, individuals face a payroll tax of 9.9%, which is the CPP payroll tax rate for covered workers. There is also a progressive income tax with eight brackets approximating the rates and brackets (federal + provincial) for a taxpayer living in Ontario, including deductions for children and a consumption tax of 8%, approximating federal and provincial sales tax net of consumption tax credits.

Table 4: Government programs and benefits

| Benefit | Demographic | Value: Model E | Assigned or SMM[a] |
|---|---|---|---|
| Universal benefits[b] | single men | 31.3 | SMM |
| | single women | 111.7 | SMM |
| | couples | 87.1 | SMM |
| Welfare benefits[c] | single men, $a <$ \$400 | \$125 | assigned |
| | single women, $a <$ \$400 | \$125 | assigned |
| | couples, $a <$ \$600 | \$250 | assigned |
| Retirement benefits | | | |
| Old Age Security | all | \$130 | assigned |
| Replacement rate | all | 25% | assigned |
| Disability benefits | | | |
| Replacement rate, *ds* 4,5[d] | single men | .18 | SMM |
| Replacement rate, *ds* 6[e] | single men | .30 | SMM |
| Temp. disab. benefits | all men | 1/8 of 75% of lost earnings | assigned |

(a) All SMM data targets are taken from the 2006-2007 cross-sectional files of the SLID since these are the only years for which information on all public and private benefits is available; all values expressed in 2002 $ Cdn (b) Targeted to match, in combination with welfare entitlements, total per-capita public and private benefits received of $35, $130 and $44.1 for prime-age non-disabled single male, single female, and non-disabled married households respectively; (c) Source: National Council of Welfare 2009 benefit tables, Disabled non-workers whose disability earnings and assets are sufficiently low receive welfare benefits; (d) Received by non-workers. Targeted to match, in combination with universal and welfare benefits, total public and private benefits of $109 received by prime-age single men in *ds* 4 and 5; (e) Received by non-workers. Targeted to match, in combination with universal and welfare benefits, total public and private benefits of $155 received by prime-age single men in *ds* 6

## 4.4 Estimation: Simulated Method of Moments.

In addition to the policy parameters discussed in the previous section, there are six sets of parameters to estimate in the full model. They are: (1) relative preference for leisure $\{\gamma_j^f, \gamma_j\}$ which evolve according to a cubic in age; (2) disability time-costs $\{\delta_h, \delta_n\}$ in each limiting *ds* state; (3) time-discount rates $\{\mathcal{B}^f, \mathcal{B}\}$, and borrowing interest rate $r_B$; (4) education- and age-specific intercepts for male and female human capital processes $\{\kappa^f, \kappa\}$; (5) female and male non-pecuniary value of marriage $\{\theta^f, \theta\}$ and exogenous matching rate $\{q^*\}$; and (6) minimum *nll* requirements for spouses $\{\underline{h}_f, \underline{h}\}$.

**Identification.** The parameters are estimated jointly through SMM. The $\gamma$'s and $\kappa$'s are primarily identified by average labor supplies of men and women at different points in their working life, and by variation in average wages by age and education. The $\delta$'s in each limiting *ds* state are identified by variation in labor supplies of unmarried prime-age men in each state, under the restrictions that $\delta_n 5 = \delta_n 4$ and $\delta_n 6 = \delta_h 6$.[32] Time-discount rates

[32]Restrictions are based on reported severity of disability in the SLID sample. The average qualitative

$\mathcal{B}^f$ and $\mathcal{B}$ are primarily identified by wealth to after-tax income ratios in households with a female and male member respectively. Borrowing interest rate $r_B$ is pinned down by the debt-to-income ratio for all households with debt. The parameters governing marital formation, in conjunction with the exogenous split probability of .05%, are identified by the evolution of marriage observed in Canadian data. Specifically, the parameters adjust so that 71.5% of working-age households are married at any point in time; 1% of this stock of marriages terminate each period; and prime-age married men earn on average $4.30 per hour more than their single counterparts, not adjusting for age. Tables 5 and 6 summarize this information and report parameter values for the workhorse model (henceforth model WH) and the extended model (model E) respectively. SMM estimates for all other models presented in section 5 are available from the authors.

assessment of the severity of work-limitation is nearly identical in *ds* 4 and 5, while reported severity for both *n*- and *h*-limiting disabilities are highest in *ds* 6.

Table 5: Estimated parameters: Model WH

| Parameter | Value: Model E | Target[a] |
|---|---|---|
| $\gamma^f$ | $.305(1.0 + 3.34E^{-2}age - 2.91E^{-3}age^2 + 5.32E^{-5}age^3)$ | mean wkly hours worked for married women 20-59[b] |
| $\gamma$ | $.597(1.0 - 7.04E^{-2}age + 3.26E^{-3}age^2 - 4.23^{-5}age^3)$ | mean wkly hours worked for healthy single men 20-59 |
| $\delta_{h,ds3}$ | 1.30 | $n$ for prime-age single men in $ds3$[c] |
| $\delta_{n,ds4}$ | 1.17 | $n$ for prime-age single men in $ds4$ |
| $\delta_{h,ds5}$ | 1.23 | $n$ for prime-age single men in $ds5$ |
| $\delta_{h,ds6}$ | 1.38 | $n$ for prime-age single men in $ds6$ |
| $\mathcal{B}^f$ | 0.979 | median wealth/income ratio for hhs with a female member |
| $\mathcal{B}$ | 0.981 | median wealth/income ratio for hhs with a male member[d] |
| $r_B$ | $4.85E^{-2}$ | median debt/income ratio for all households |
| $\kappa^f$ | $1.82 + .356ed + 3.27E^{-2}age - 3.67E^{-4}age^2$ | mean wages by age and education for female workers |
| $\kappa$ | $2.12 + .278ed + 3.09E^{-2}age - 3.17E^{-4}age^2$ | mean wages by age and education for male workers[e] |
| $\theta^f$ | $6.19E^{-3}$ | share of divorces per 1000 married households |
| $\theta$ | $5.38E^{-2}$ | average wage differential between prime-age married and single men |
| $q^*$ | .211 | share of households that are married[f] |
| $\underline{h}_f$ | n/a | married female $h$ |
| $\underline{h}$ | n/a | married male $h$[g] |

(a) All labor and income targets come from the 2002-2007 cross sectional files of the SLID. Wealth targets are taken from public use version of the 2005 Survey of Financial Security. Time-use targets are taken from the 2004 General Social Survey on Canadian time use. 'Prime age' refers to individual and households age 25-59. (b) Hours worked for non-disabled single males age 20-29/ 30-39/ 40-49/ 50-59 are 28.8/ 38.5/ 37.8/ 31.7. For married women, the corresponding hour targets are 24.8/ 26.2/ 28.0/ 21.9. (c) The targets for each $ds$ state are 30.9/ 24.4/ 20.9/ 9.7. (d) 'Wealth' includes all financial assets plus the termination value of pension entitlements. Income refers to after-tax income. The median wealth to income ratio for all prime-age hhs with a male (female) member is 3.04 (3.06), and the median debt-to-income ratio for all hhs is .37. (e) The specific targets are: (1) the raw educational difference in prime-age wages by education category for male ($6.05) and female ($5.83) workers; wages for young 25-34 male ($19.6) and female ($16.6) workers; wages for young 35-44 male ($23.1) and female ($18.3) workers; and wages for older 45-55 male ($24.7) and female ($18.7) workers. (f) 1% of marriages (10 in 1000) among households under 66 terminate in steady state, while prime age married men earn $4.30 per hour more on average than prime age single men. 71.5$ of households between 25 and 60 are married. (g) These targets are 38.5 hours of $nll$ for wives and 25.7 hours for husbands. The slight differences between these targets and the values for $nll$ in table 4.3 comes from small differences in the simulated and real age profile of marriage and the fact that we impose an exogenous fertility process on the model that is identical for married and single women.

Table 6: Estimated parameters: Model E

| Parameter | Value: Model E | Target[a] |
|---|---|---|
| $\gamma^f$ | $.561(1.0 - 9.58E^{-3}age - 1.47E^{-3}age^2 + 3.51E^{-5}age^3)$ | mean wkly hours worked for married women 20-59[b] |
| $\gamma$ | $.364(1.0 + .140age - 7.80E^{-3}age^2 + 1.11^{-4}age^3)$ | mean wkly hours worked for healthy single men 20-59 |
| $\delta_{h,ds3}$ | 1.22 | $n$ for prime-age single men in $ds3$[c] |
| $\delta_{n,ds4}$ | 1.12 | $n$ for prime-age single men in $ds4$ |
| $\delta_{h,ds5}$ | 1.20 | $n$ for prime-age single men in $ds5$ |
| $\delta_{h,ds6}$ | 1.50 | $n$ for prime-age single men in $ds6$ |
| $\mathcal{B}^f$ | 0.982 | median wealth/income ratio for hhs with a female member |
| $\mathcal{B}$ | 0.958 | median wealth/income ratio for hhs with a male member[d] |
| $r_B$ | $5.39E^{-2}$ | median debt/income ratio for all households |
| $\kappa^f$ | $5.97 - 2.77E^{-2}ed - .268age + 3.90E^{-3}age^2$ | mean wages by age and education for female workers |
| $\kappa$ | $15.0 + .493ed - .601age + 6.41E^{-3}age^2$ | mean wages by age and education for male workers[e] |
| $\theta^f$ | $4.21E^{-4}$ | share of divorces per 1000 married households |
| $\theta$ | $1.63E^{-2}$ | average wage differential between prime-age married and single men |
| $q^*$ | .221 | share of households that are married[f] |
| $\underline{h}_f$ | $.228(\overline{h}_f + \overline{h})$ | married female $h$ |
| $\underline{h}$ | $.387(\overline{h}_f + \overline{h})$ | married male $h$[g] |

(a) All labor and income targets come from the 2002-2007 cross sectional files of the SLID. Wealth targets are taken from public use version of the 2005 Survey of Financial Security. Time-use targets are taken from the 2004 General Social Survey on Canadian time use. 'Prime age' refers to individual and households age 25-59. (b) Hours worked for non-disabled single males age 20-29/ 30-39/ 40-49/ 50-59 are 28.8/ 38.5/ 37.8/ 31.7. For married women, the corresponding hour targets are 24.8/ 26.2/ 28.0/ 21.9. (c) The targets for each $ds$ state are 30.9/ 24.4/ 20.9/ 9.7. (d) 'Wealth' includes all financial assets plus the termination value of pension entitlements. Income refers to after-tax income. The median wealth to income ratio for all prime-age hhs with a male (female) member is 3.04 (3.06), and the median debt-to-income ratio for all hh's is .37. (e) The specific targets are: (1) the raw educational difference in prime-age wages by education category for male ($6.05) and female ($5.83) workers; wages for young 25-34 male ($19.6) and female ($16.6) workers; wages for young 35-44 male ($23.1) and female ($18.3) workers; and wages for older 45-55 male ($24.7) and female ($18.7) workers. (f) 1% of marriages (10 in 1000) among households under 66 terminate in steady state, while prime age married men earn $4.30 per hour more on average than prime age single men. 71.5$ of households between 25 and 60 are married. (g) These targets are 38.5 hours of $nll$ for wives and 25.7 hours for husbands. The slight differences between these targets and the values for $nll$ in table 4.3 comes from small differences in the simulated and real age profile of marriage and the fact that we impose an exogenous fertility process on the model that is identical for married and single women.

# 5 Results

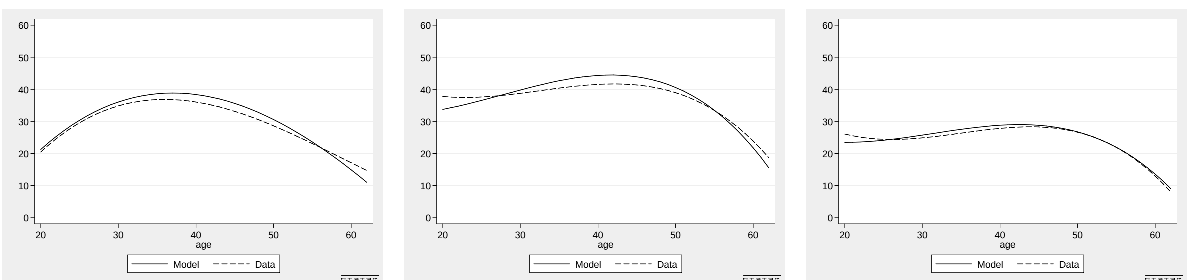
We now turn to assessing models' performance and, specifically, the empirical relevance of the mechanisms proposed in model E. We begin by evaluating the fit of model E to some basic observations about life cycle labor supply and asset accumulation across marital states. Next, we discuss its performance, relative to the workhorse (WH) model from section 2, in replicating untargeted dynamic labor supply and wage patterns following disability onset. We also quantify the relative contribution of different elements of model E by separately shutting down, (1), optimal task sharing/home production and, (2), endogenous wages/human capital. We also examine other interesting features of the proposed framework, including the specific roles of home- vs. work-limiting shocks and the role of endogenous marriage. Moreover, we report some direct microdata evidence supporting the importance of home production in families facing disability. We conclude with an extension in which we explore the intuitively appealing possibility that individuals may recoup time by accessing a market for *nll* services. Table 7 provides a synopsis of the models compared in this numerical analysis.

Table 7: Model specifications compared in numerical analysis

| Name | Description |
|---|---|
| Model WH | work-horse model |
| Model E | full extended model |
| Model E-1 | Model E w/o home production |
| Model E-2 | Model E w/o human capital motive (exogenous wages) |
| Model E-3 | Model E with market for *nll* services: low price |
| Model E-4 | Model E with market for *nll* services: high price |

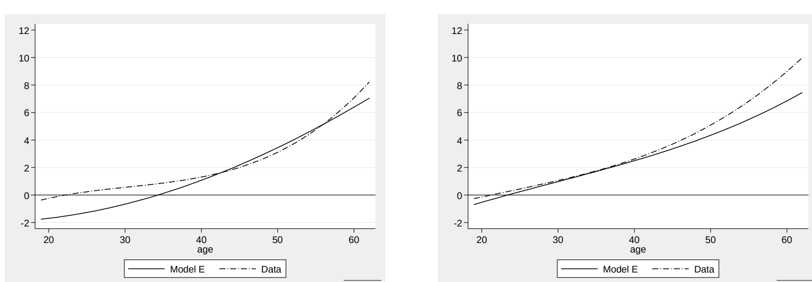
**Life cycle patterns.** We begin by assessing the extended model's ability to generate reasonable profiles of labor and asset holding over the life cycle. These features provide both a check on the quality of the estimation and an assessment of the model's ability to match some basic out-of-sample moments. Figures 6(a) through 6(c) show that the evolution of hours worked for single men, married men (untargeted), and married women in model E is very similar to the profiles estimated from SLID data. Although single women play no direct role in the calibration or results, we note that the model generates a weekly labor supply for prime-age single women of 34 hours, which is on the high end of the reasonable range of values. Figures 7(a) and 7(b) show the evolution of wealth-to-income ratios for single and married male-headed households up to age 62 against the corresponding cross-sectional profiles from the 2005 SFS. As these profiles are untargeted, the model does not generate perfect fits, with too much debt-holding among young single men and too little accumulation of wealth among married households after 50. However, in both model and data, assets increase over the working life in a convex fashion, with married households holding more wealth relative to income in both the simulated and real data over the working life. The higher saving rate of marrieds replicates a well-known and attractive feature of endogenous marriage models: see for instance Guner and Knowles (2003).[33]

Figure 5: Life cycle profiles of male and (female) spousal labor




(a) Hours: single men (b) Hours: married men (c) Hours: married women

Figure 6: Wealth to income ratios over the life cycle




(a) Wealth/income ratio: Single males (b) Wealth/income ratio: Married males

[33]We do not plot the evolution of wages, since this is directly targeted for men and women. In all models, the cross-sectional variance of wages for both men and women falls between .24 and .27.

**Own and spousal responses to disability onset.** Figures 7 and 8 plot estimates of the $\dot{\delta}$'s from equation (8) and $\overline{\delta}$'s from (9), using average weekly hours (figure 7) and participation (figure 8) as dependent variables.[34] Both sets of results are from a pooled sample of men and present estimates from model WH (left panel) and model E (right panel) against the corresponding results from the SLID.[35] The top panel shows the $\dot{\delta}$'s for the pooled sample of men, the middle panel plots $\overline{\delta}$ from the same sample, and the bottom panel plots $\dot{\delta}$'s estimated on the sample of wives. In all graphs solid lines show simulation results and dotted lines show corresponding results from the SLID. Small nodes indicate where the estimates differ from zero at the 10% level, while large nodes indicate significance at the 5% level.

Numerical results confirm the analytical predictions from section 2: the workhorse model fails to generate realistic post-onset labor supply patterns. Men drop their labor supply precipitously at onset, with the drop significantly greater for married men during the first few years after onset, as shown in the middle left panel. Starting two years after onset, there is a partial recovery in hours worked for both types of men which lasts for several periods. Since men's responses depend almost entirely on current $ds$ state, rather than past history of shocks, this pattern is not surprising. Participation results for model WH are even worse, indicating a strong tendency to temporarily retire in the year of onset. On the other hand, the workhorse model (like model E) does not produce a significant added worker effect, consistent with the empirical evidence but not with the theory developed in section 2. There are two reasons for this: first, disability onset in the workhorse model has relatively small

[34]The simulated weekly hours variable is actually the average of current period hours and lagged hours. This is because, in the SLID population, disability shocks arrive continuously, while in the model they can arrive only at the beginning of a period, leading to a potential mismatch between model and data in the period of time affected by a 'reported' shock.

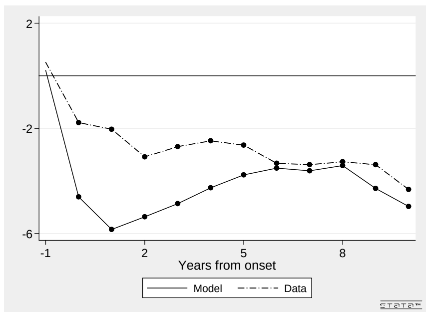
[35]To construct model samples we simulate 25,000 male and female individuals and follow them, and their partners while married, for (at most) 81 periods. From this simulated sample, we keep only males between 25 and 59, and randomly sample five consecutive observations from this interval. The control group consists of men observed between 2 and 5 years before onset. The treatment, or 'post-onset', group consists of men who report at least one current disability during the five-year window in which we observe them (that is, who would be identified as disabled in our SLID sample). We weight the data to generate a degree of chronicity—i.e. the share of periods in which disability is reported—comparable to the SLID sample over a ten-year post-onset period. Finally we run OLS regressions controlling for education, $rsk$ (as a proxy for self-assessed health), and a cubic in age. The reported results are averages over ten randomly drawn samples from the simulated data.

wealth effects. Most disability is temporary and, because it is not associated to long-term human capital loss, has small expected effects on permanent income. Second, married men who become *permanently* disabled face a heightened risk of divorce. Since we focus here on men who do not change marital status over the sample, these more seriously disabled married men are in general less likely to appear in the regression sample. Thus, while female labor supply does increase with years from onset, the effect never becomes significant.

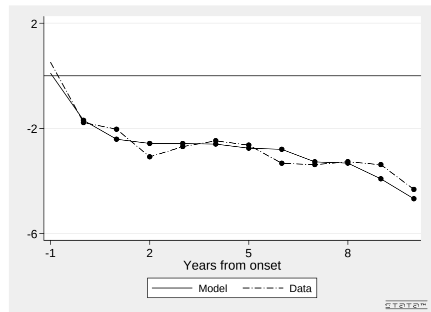
By contrast, with the addition of endogenous wages and home production, model E goes a long way toward reconciling theory and evidence, producing post-onset labor supply patterns for single and married men that are much closer to microdata observations. The mechanisms explaining the improved fit are investigated in section 5.1.

**Wages following disability onset.** Figure 9 plots the evolution of log wages after disability onset in model E against corresponding patterns in the data, disaggregated by marital status. We compare two sets of results. In the upper panel of figure 9, we report the selection-corrected SLID results from section 3 against the full sample of men in the simulation (without conditioning on participation), disaggregated by marital status. In the bottom panel of figure 9 we plot the evolution of workers' wages (i.e. wages with no correction for selection) following disability onset for both real and simulated samples. For selection-adjusted wages, married men in model E experience a small, roughly 6%, long-run decline in log wages, significant at the 10% level by nine years post-onset. The mean log wage of single men, however, falls persistently post-onset and is significantly below the mean pre-onset log wage within five years from onset. For the samples with no selection adjustment, we find no significant effect of years from onset on observed wages in either Model E or the SLID data, regardless of marital status. This finding most likely reflects the fact that most of the response to disability occurs on the extensive (participation) margin. Finally, we note that the ability of full-time workers to return to work at their previous wage under Workers Compensation legislation is important in generating these wage profiles: if this provision of WC were eliminated in the model, wage drops post-onset would be larger and significant for both married and single men, regardless of selection.

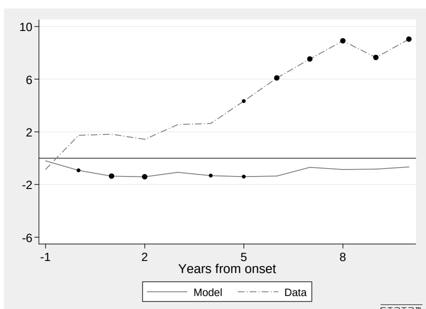
Figure 7: Average weekly hours following onset: Workhorse model vs. Model E



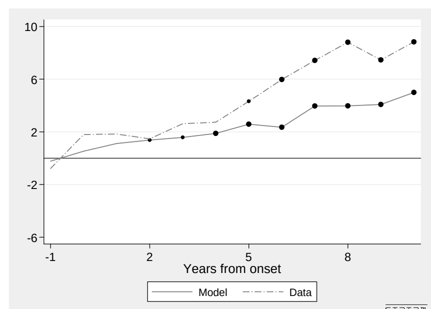

(a) All men: Model WH



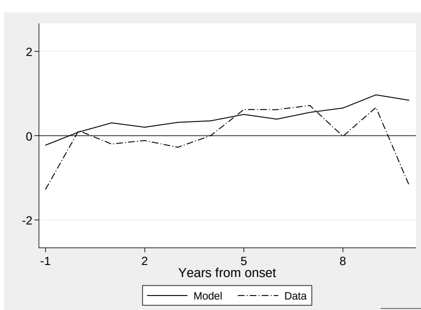

(b) All men: Model E



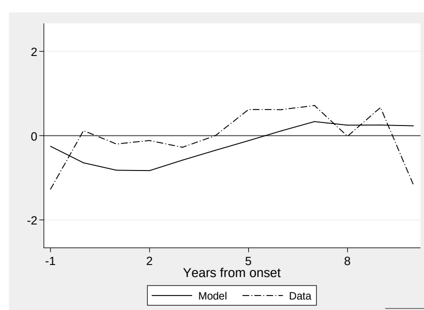

(c) Married-single difference: Model WH




(d) Married-single difference: Model E

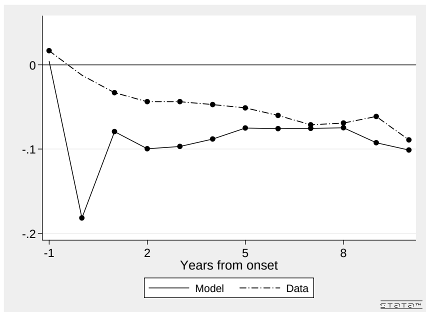



(e) Wives: Model WH

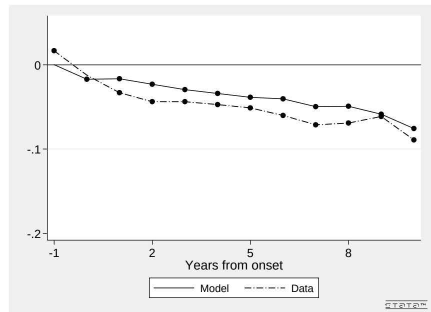



(f) Wives: Model E

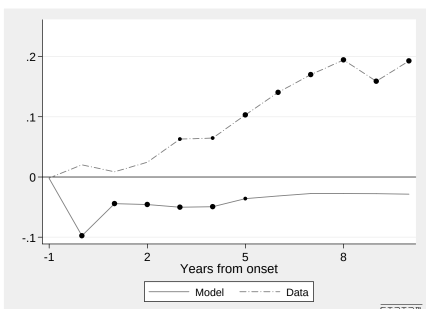
Figure 8: Annual participation rates following onset: Workhorse model vs. Model E



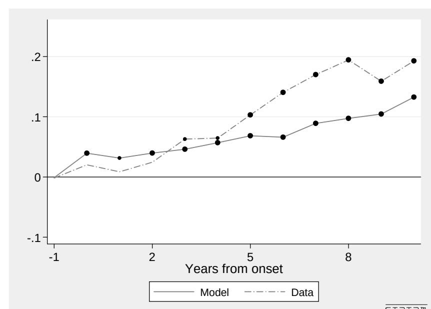

(a) All men: Model WH



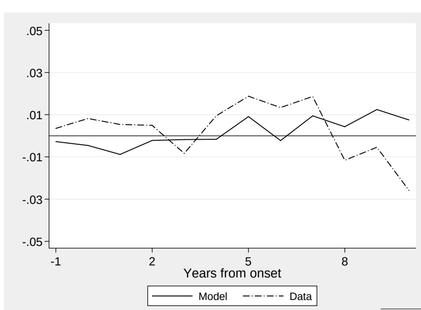

(b) All men: Model E



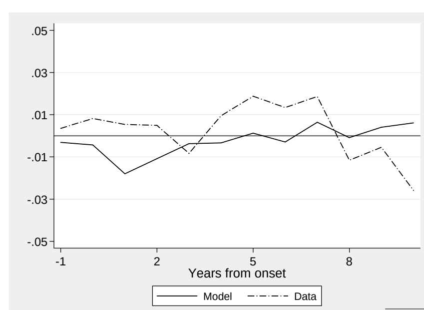

(c) Married-single difference: Model WH




(d) Married-single difference: Model E

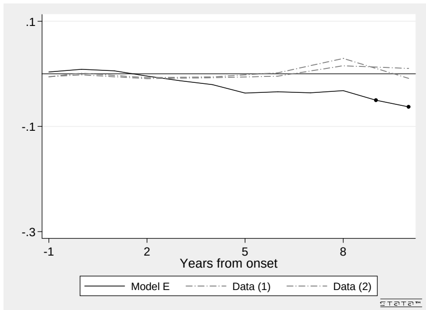



(e) Wives: Model WH

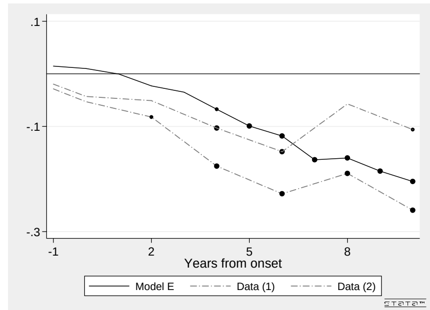



(f) Wives: Model E

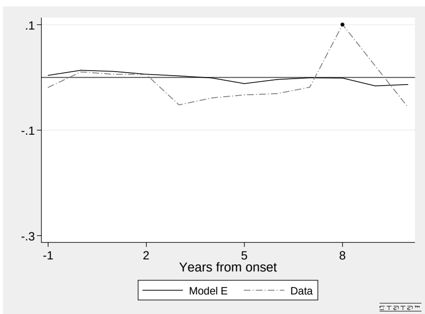
Figure 9: Wage declines in model E vs. data



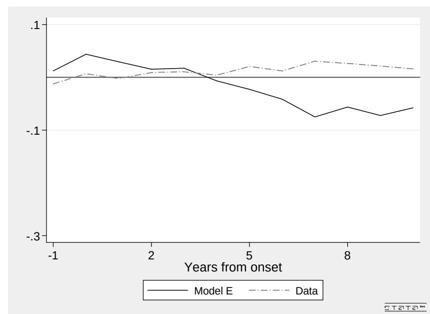

(a) Married men: full sample, selection-adjusted




(b) Single men: full sample, selection-adjusted




(c) Married men: workers only




(d) Single men: workers only

## 5.1 Inspecting the mechanisms of the extended model

We can more closely examine the roles of the two mechanisms at work in model E by alternately shutting down home production (model E-1; figure 10) and human capital accumulation (model E-2; figure 11). For each restricted model, we re-estimate all remaining parameters through SMM and then plot the same set of results shown in figure 7: the left hand panels of figures 10 and 11 show changes in average weekly post-onset hours of all men; the middle panels show estimated difference-in-differences between married and single men's changes in post-onset average weekly hours; and the right panels show changes in average spousal post-onset weekly hours. As before, all results are plotted against the corresponding estimates from the SLID.

Figure 11 shows that adding endogenous home production to model WH provides a small improvement in the fit of weekly hours worked. Since disability makes husbands less efficient in the home as well as the market, some couples find it optimal for the husband to refocus on market work following the onset of a mostly home-limiting disability. This effect eliminates the negative difference between married and single men's post-onset labor supplies, thereby partially solving the first 'puzzle' laid out in section 2. It also eliminates the small, but insignificant, added worker effect visible in the WH results.

Figure 10 shows the results from a version of model E in which we retain the human capital accumulation process but shut down the technology for home production, replacing *nll* for married men and women with the mean age-adjusted estimates from the 2005 Canadian GSS, as in model WH. When home production is shut down, an added worker effect emerges, growing over time and eventually becoming significant at 10%, eight years post-onset. The estimated difference between single and married changes in labor supply is also smaller than in model E, though this positive difference is still present and significant at later years from onset. Finally, although we omit the relevant figures for space, the decline in labor supply for married men is sufficiently large to generate significant negative effects on wages, reaching 9% of pre-onset wages ten years after onset, as reported in appendix Table 17.

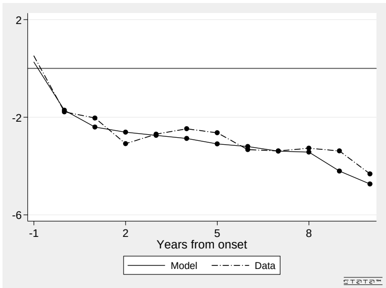
Taken together, these results suggest that both optimal task sharing and a human capital process are necessary to simultaneously resolve the 'puzzles' outlined in section 2, but that human capital accumulation plays the bigger role. The explanation is simple: the dynamic human capital motive gives disabled men an incentive, absent in model WH, to maintain their labor supply. The incentive is larger for married men since they have more human capital (higher wages) on average, and because loss of human capital makes their marriage less stable.[36] The presence of intra-household task sharing provides an effective mechanism by which couples cooperate to support husband's labor supply.

**Testing model fit.** The graphical results provide simple illustrations of model fit. In addition, table 8 reports $\chi^2$ tests for the differences in labor supply responses between simulated and SLID data.[37] This is done by pooling together real and simulated data and

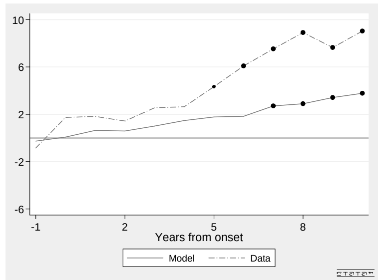
[36]Also see the discussion in appendix B. In earlier results, for a model without endogenous marital transitions, the estimated $\bar{\delta}$'s in model E-1 were in fact insignificantly different from zero at all years post-onset.

[37]In contrast to the results presented above, which were smoothed averages of multiple draws from the simulated economy, we report comparisons between SLID data and a single random draw from simulated

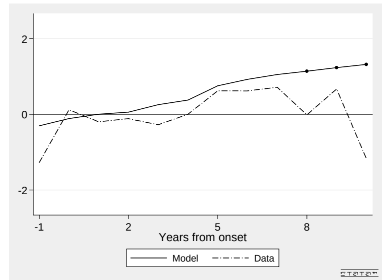
Figure 10: Weekly hours responses in model E-1: No home production




(a) All men

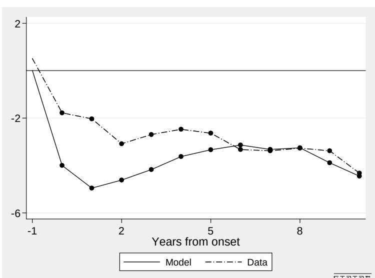



(b) Married-single difference

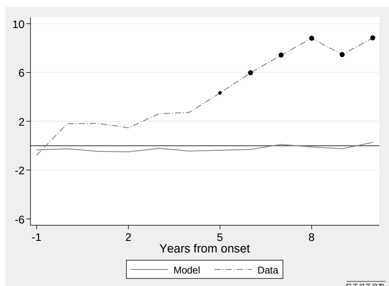



(c) Wives

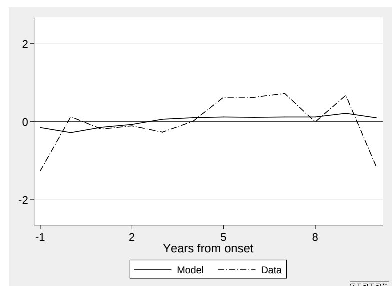
Figure 11: Weekly hours responses in model E-2: Exogenous wages




(a) All men




(b) Married-single difference




(c) Wives

estimating the following reduced-form system of equations for men and women:

$$
\begin{aligned}
y_{it} =& \zeta_0(X_{it}, \mathcal{F}(age_{it}, \eta_i)) + \mathrm{S}_i + \eta_i + \sum_k [\zeta_{1k} A_{kit} + \zeta_{2k} A_{kit} \times \mathrm{S}_i \\
& + \zeta_{3k} A_{kit} \times \eta_i + \zeta_{4k} A_{kit} \times \mathrm{S}_i \times \eta_i] + \epsilon_{it} \\
y_{it}^f =& \zeta_0^f(X_{it}, \mathcal{F}(age_{it})) + \mathrm{S}_i + \eta_i + \sum_k [\zeta_{2k}^f A_{kit} \times \eta_i + \zeta_{4k}^f A_{kit} \times \mathrm{S}_i \times \eta_i] + \epsilon_{it}^f
\end{aligned} \tag{17}
$$

where $y_{it}$ is the economic measure of interest; S is an indicator variable taking the value one if the observation is from the SLID and zero otherwise; $\eta$ is an indicator variable taking the value one if the individual is married and zero otherwise; $\mathcal{F}$ is a cubic in age, alone and interacted with $\eta$ for males; and $X$ contains all the demographic variables from equations (8)

data. We sequentially re-tested all results using additional random draws from the simulated data, confirming the reported results: in the additional draws, Model WH was always rejected, and model E almost never rejected at the 10% level.

Table 8: Tests of differences between model and data

| | | | | |
|---|---|---|---|---|
| Model E: | $H_0$ : | $\zeta_2 = \zeta_4 = \zeta_4^f = 0$ | $\chi^2 = 37.1$ | $prob = 0.284$ |
| Model WH: | $H_0$ : | $\zeta_2 = \zeta_4 = \zeta_4^f = 0$ | $\chi^2 = 103.2$ | $prob = 0.000$ |
| Model E-1: | $H_0$ : | $\zeta_2 = \zeta_4 = \zeta_4^f = 0$ | $\chi^2 = 44.2$ | $prob = 0.092$ |
| Model E-2: | $H_0$ : | $\zeta_2 = \zeta_4 = \zeta_4^f = 0$ | $\chi^2 = 96.2$ | $prob = 0.000$ |

and (9) interacted with S, plus health status and a constant. As in equation (8), $A_k$ denotes an indicator for year from onset with $k \in \{-1, 10\}$. Coefficient vector $\boldsymbol{\zeta_1}$ roughly captures the change in $y$ relative to the pre-onset control group at each post-onset year ($\Delta^k y$) for single men in the simulation; $\boldsymbol{\zeta_2}$ captures the difference in single male $\Delta^k y$ between the real and simulated samples; $\boldsymbol{\zeta_3}$ captures the difference in $\Delta^k y$ by marital status in the simulated data; $\boldsymbol{\zeta_4}$ captures the difference-in-difference in $\Delta^k y$ between single and married men, taken across the real and simulated samples. For women, $\boldsymbol{\zeta_1}^f$ and $\boldsymbol{\zeta_3}^f$ are constrained to be zero since there are no spouses in single male households by definition; $\boldsymbol{\zeta_2}^f$ captures changes in female $y$ relative to the pre-onset control group by year from onset; and $\boldsymbol{\zeta_4}^f$ captures the difference in wives' $\Delta^k y$ between the real and simulated samples.[38]

We report test statistics and p-values from tests of the joint null hypothesis that $\{\zeta_{2k}, \zeta_{4k}, \zeta_{4k}^f\}_{k=0}^{10} = 0$, both for model E and for each of the comparison models examined so far: model WH, model E-1, and model E-2. Test results are broadly consistent with the graphical evidence in the previous two subsections. While the disability patterns generated by model E are not perfect, they cannot be jointly rejected, whereas those generated by model WH and model E-2 are both strongly rejected. Model E-1 (model E with no home production) is an intermediate case; it is rejected at the 10% level but not at the conventional 5% level. These findings suggest that the presence of endogenous wages is very important to the relative success of the model, and that intra-household time sharing plays a supporting, though still important, role.

[38] We apply a seemingly unrelated regression estimator adjusted to allow for covariation in the error terms across equations.

## 5.2 Extensions and empirical evidence

### 5.2.1 Disability and marriage

A very attractive feature of the SLID is that it allows us to distinguish between work-limiting and home-limiting disability shocks. The latter are important because they make the wife's market labor supply less effective as a form of insurance when husbands experience a shock. Therefore, we would expect different types of disability shocks to have different impacts on the stability of marriage when spouses engage in specialization in the market or at home. In this section, we report some results that speak to both these possibilities. We first examine the reduced-form effects of marital status on male labor supply for men experiencing different types of limiting disability shock, comparing the simulated data in model E to the 2002-2007 cross sectional files of the SLID (table 9). We then examine the endogenous distribution of disability across marital states in the SLID, model E and model WH (table 10).

Table 9 shows results from OLS regressions of average weekly hours worked on marital status, dummies for home-limiting or work-limiting disability, interactions between marital status and both types of disability, and (in the SLID) other demographic variables. Standard errors are clustered at the individual level. Unsurprisingly, work-limiting disability ($\delta_n$) has a larger level effect on hours worked than home-limiting disability ($\delta_h$). The former induces both a substitution and time-loss effect on labor supply, while the latter induces only a time-loss effect. More interesting, reduced-form correlations between marital status and disabled labor supply are broadly similar in the model and the data: the 'return' to being married, in terms of additional hours worked while disabled, is nearly identical for work-limiting shocks, though higher in model E for home-limiting shocks. Moreover, in both model and data, the *relative* effect of marriage on disabled labor supply is larger (as shown in columns 3 and 5 of table 9) for home-limiting shocks. These results are intuitively appealing: when a married man experiences a disability that is mainly home-limiting, the couple's optimal strategy is typically to reduce the husband's *nll* activity (as much as feasible) and increase his specialization in the labor market.

The ability for couples to 'manage' home-limiting disability shocks has obvious implications for the stability of marriage. While this paper focuses on the economic effects of disability *conditional* on marital status, table 10 provides an indication of how sorting in the marriage market both determines and reflects our main findings. The upper panel of the table shows the distribution across different *ds* states among currently disabled males by marital status. The lower panel reports a measure of the chronicity of disability: specifically, the mean number of periods within a randomly drawn six-year interval in which the individual reports a limiting disability, conditional on reporting *at least one* disability during the interval. We can see that the incidence of *ds* 6, the most severely limiting state, is about 5 percentage points higher for singles than for marrieds in the SLID and in model E, while strict home-limitations, *ds* 3, are more prevalent among marrieds by 9 percentage points in the SLID (4.3% in model E). As well, the frequency of disability reports over a six-year interval is lower for marrieds by about 5/10 of a period in model E, and 4/10 in the data. By contrast, the differences by chronicity and, especially, type of disability across marital status are much more muted in model WH. The relative lack of marital sorting based on chronicity is due in large part to the limited importance of disability shocks, relative to other types of productivity shocks, in the workhorse model. The lack of sorting across *types* of disability speaks in part to the inability of spouses to manage home limiting shocks relative to work-limiting shocks in model WH. With *nll* requirements set exogenously, there is no scope for post-onset specialization in the market and no relative increase in marital stability associated to strictly home-limiting shocks.

### 5.2.2 Data evidence on time use and disability

Another interesting implication of our results is that added worker effects may exist, but are concentrated in the household sector, rather than the market sector. In general it is difficult to find direct evidence of changes in home production due to disability onset. Time spent on *nll* activities, such as housework, is not available in most income surveys (including the SLID), while time-use surveys, like the 2005 General Social Survey for Canada and the American Time Use Study, typically provide time-use and demographic information only for one household member. Our model makes no direct predictions about the time that

Table 9: Effects of home- and work-limiting shocks on male weekly labor supply, by marital status

| dep. variable: week work hours | SLID coef | Proportional change | Model coef | Proportional change |
|---|---|---|---|---|
| $\delta_h$ | -4.59 | | -5.44 | |
| | (.874) | | (.569) | |
| $\delta_n$ | -12.33 | | -11.66 | |
| | (0.956) | | (.618) | |
| *married* | 3.50 | | 5.27 | |
| | (.336) | | (.144) | |
| $married \times \delta_h$ | 2.81 | .61 | 4.74 | .87 |
| | (1.03) | | (.605) | |
| $married \times \delta_n$ | 3.85 | .31 | 4.33 | .37 |
| | (1.17) | | (.665) | |

Table 10: Type of limiting *ds* by marital status for prime-age men

| | SLID | | Model E | | Model WH | |
|---|---|---|---|---|---|---|
| | Married | Single | Married | Single | Married | Single |
| *ds* 3 (%) | 22.2 | 13.2 | 19.9 | 15.6 | 18.7 | 17.7 |
| *ds* 4 (%) | 7.6 | 9.0 | 9.2 | 8.5 | 8.5 | 10.3 |
| *ds* 5 (%) | 45.4 | 47.5 | 45.7 | 45.5 | 46.2 | 44.6 |
| *ds* 6 (%) | 24.8 | 30.3 | 25.2 | 30.4 | 26.8 | 27.4 |
| *ds* freq over 6 years | 2.59 | 2.98 | 2.54 | 3.05 | 2.66 | 2.79 |

a disabled individual would spend on household tasks, even conditional on a given level of market work.[39] The model does, however, predict that *wives* of disabled men increase their own share of home production, conditional on husbands remaining the main household earners and continuing to work close to pre-onset hours. When a husband supplies few hours of market work, we would expect to see small or negative effects of his disability on wife's *nll*.

Table 11 reports empirical evidence in support of this conjecture. Using the same sample from the 1999-2005 PSID used to estimate our *nll* sharing technology,[40] we regress wives' average weekly reported hours of housework on an indicator for dual-earner status, the couple's wage ratio (interacted with dual-earner status; for single-earner or non-working

[39] A disabled husband substitutes away from *nll* activities because they are costly in terms of time and effort (substitution effect). However *nll* activities in which he does engage consume more of his time (time-loss effect).

[40] The sample is the same, with the restriction that spouses may not be more than five years apart in age.

Table 11: PSID: Wives' housework and husband's disability status

| Wife's hours of housework $h_f$ | All | 51-65 | 36-50 | 20-35 |
|---|---|---|---|---|
| $n$ | 0.01 | 0.10 | 0.11 | 0.08 |
| | (0.55) | (0.02) | (0.02) | (0.04) |
| $ds$ | $-3.33$ | $-1.82$ | $-5.44$ | $-5.54$ |
| | (1.24) | (1.76) | (1.62) | (3.56) |
| $ds \times n$ | 0.11 | 0.09 | 0.14 | 0.16 |
| | (0.03) | (0.05) | (0.04) | (0.08) |
| average $h_f$ | 18.8 | 19.2 | 18.6 | 18.7 |
| $F_2$ | 1% | 10% | 1% | 20% |

households '$wr$' is not observed), family income, a dummy for husbands reporting work-limiting disability, husband's average weekly market hours, and the interaction of disability status and market hours ($ds \times n$). Column 1 reports results from this regression for all couples under 66. The next three columns document this relationship by age category: 51-65; 36-50 and <36. The first six rows report estimated coefficients (and standard errors); the seventh row presents average reported hours of housework for wives in the age range; the last row shows results of an $F$-test for joint significance of $ds$ and $ds \times n$.

The results support the general implication of the model: for men who work very little, a husband's disability reduces the wife's time devoted to *nll*, but this effect is reduced, and eventually reversed, for disabled husbands contributing sufficient hours of market work. To put these results into perspective, the wife of a currently disabled husband working 45 hours a week, performs on average 1.6 hours—or about 9%—more housework per week than the average wife. The joint effect of disability, and disability interacted with hours, on predicted housework is jointly significant at conventional levels for all groups except the youngest, for which we have only 150 observations on disabled husbands; the joint test of $n$, $ds$ and $ds_n$ (not reported) is always significant at 1%.

#### 5.2.3 A 'market for time'

Finally, we consider the possibility that households might be able to offset time devoted to *nll* activities, either by formally purchasing *nll* services in the market, or informally acquiring them from other household or extended family members. Child-care is the most obvious form of such 'time purchases'. In the context of disability, physiotherapy, rehabilitation services or in-home support are also examples that intuitively fit our framework.[41]

To investigate this possibility we extend the model by allowing households access to a 'market for time'. A unit of time input, $h_p$, costs $p_h$ and delivers $ah_p^{q1} = 1.494h_p^{.776}$ units of effective time to the household. That is, we set the effective returns to time purchased on the market equal to the transfer rate of *nll* time into *nll* services for wives. This functional form assumption is made for convenience, but it captures the main feature we would expect for such a technology: specifically, individuals purchase *nll* inputs efficiently so that the initial return to $h_p$ in terms of additional free time is high, then declines with each additional unit purchased. In addition, this assumption on time production loosely reflects the idea that, to the extent that extended family members may provide *nll* services, they come predominantly from women. Finally, we assume that time purchased in the market is fully transferable within couples.

To check for robustness of our results, we set $p_h$ to take both a low and a high value ($20 in model E-3 and $25 in model E-4, respectively).[42] For these exercises we include two additional parameters and targets in the SMM estimation procedure. The additional targets are the data proxies for '*nll*' work ($h$) of single men and women. The additional estimation parameters are $\{\overline{h}_f \geq h_f, \overline{h} \geq h\}$, i.e. the time that must be devoted to *nll* services by singles when $h_p = 0$.[43] As before, married couple's joint *nll* requirement is $\overline{h}_f + \overline{h}$, and husbands (wives) must devote at least $\underline{h}$ ($\underline{h}_f$) to the joint *nll* burden *before* purchased time offsets are applied. Estimated values for $\overline{h}_f$, $\overline{h}$, $\underline{h}_f$ and $\underline{h}$ are presented in the top panel of table 12. Further details of the estimation procedure, including full sets of parameter estimation

[41]A recent and interesting literature has documented the economic consequences of cohabitation—see, for instance Gemici and Laufer (2009) and Kaplan (2010). In our model the ability to receive time transfers from household members *other than* partners, could also be an important determinant of time management, and hence the effects of disability within different types of households. Recent research by Angelucci et al. (2010) confirms that extended families provide some informal insurance.

[42]The price $p_h$ is understood as a pecuniary cost; however, it might also represent the pecuniary equivalent of informal costs associated to family members' help. For example, a sibling might be willing to babysit with the understanding that she can borrow the car and eat from the fridge while the homeowners are away.

[43]Since $\overline{h}$ differs by age, education and the presence of children, we actually estimate the difference between the mean observed $h$ ($h_f$) in the GSS for prime age single men (women) and the $\overline{h}$ ($\overline{h}_f$) that generates the same value in the model, under the assumption that this difference is constant across age-education-gender cells. This difference, in weekly hours, is what is reported as $\overline{h}$ and $\overline{h}_f$ in table 12.

results, are available upon request.

The middle panel of table 12 shows a few interesting results from the 'market for time' simulations. We report the mean $h_p$ purchases generated by the model for different types of household in models E-3 and E-4. Market purchases of *nll* vary inversely with the price of *nll* for all types of household, as we would expect. They are much higher for male-headed than for female-headed households. Among male-headed (single and married) households, they are highest when the head is suffering from a home-limiting disability, and somewhat higher when the head is suffering from a work-limiting disability. (Although not shown in the table, the few households suffering from an *exclusively* work-limiting disability purchase slightly less $h_p$ than healthy households. Those with a permanent, exclusively work-limiting, disability purchase almost none.) Overall, these results confirm that the ability to offset the time loss due to disability is not negligible, especially when disability affects people in the home as well as at work.

Finally, we look at the main labor supply results in the market-for-time models. The labor supply, participation and wage paths following disability onset, generated by model E-3 and E-4, show a very good fit and are visually similar to the results from model E. For space we omit the corresponding graphs, but report the numerical results in appendix tables 19 and 20. The last row of table 12 reports the result of a joint $\chi^2$ test of $\{\boldsymbol{\zeta_2}, \boldsymbol{\zeta_4}, \boldsymbol{\zeta_4^f}\}$ in equation (17) for model E, model E-3 and model E-4, with weekly hours worked as the dependent variable. A market for time slightly improves the overall fit of model E, with the best results generated by model E-3. The better fit is mainly due to the larger long-run declines in the labor supply of single men following onset. While time purchases can help men weather short-term disabilities, long-term disabilities force singles to substitute away from market and toward home production of *nll*, while strongly raising the probability that a man becomes or remains single.

Table 12: Results: Model E-3 and E-4

| | Model E | Model E-3 ($p_h = \$20$) | Model E-4 ($p_h = \$25$) |
|---|---|---|---|
| | | Parameter estimates | |
| $\overline{h}_f$ | n/a | 0.90 | 0.29 |
| $\overline{h}$ | n/a | 4.45 | 2.47 |
| $\underline{h}_f$ | $.228(\overline{h}_f + \overline{h})$ | $.235(\overline{h}_f + \overline{h})$ | $.253(\overline{h}_f + \overline{h})$ |
| $\underline{h}$ | $.387(\overline{h}_f + \overline{h})$ | $.455(\overline{h}_f + \overline{h})$ | $.433(\overline{h}_f + \overline{h})$ |
| | | Total $h_p$ purchases | |
| All single males | n/a | 7.9 | 4.4 |
| All single females | n/a | 2.2 | 1.0 |
| All married couples | n/a | 7.2 | 3.8 |
| Healthy male-headed households | n/a | 6.6 | 3.5 |
| Male-headed households with $\delta_h > 1$ | n/a | 12.4 | 7.5 |
| Male-headed households with $\delta_n > 1$ | n/a | 10.9 | 6.7 |
| | | $\chi^2$ test results | |
| $\chi^2$ statistic | 37.1 | 29.8 | 36.9 |
| $p$-value | .28 | .63 | .29 |

# 6 Conclusion

This paper investigates how cross-sectional health risk can be insured within households over the life cycle. Using panel information about the timing, persistence and responses to disability shocks among Canadian men, we show that observed patterns of labor supply and wages after disability onset convey valuable information about the way individuals and couples respond to shocks. Our findings suggest that the large measured persistence of wage shocks may in part be due to changes in intra-household time allocations and dynamic human capital accumulation. Our analysis focuses on the way in which workers and their partners jointly deal with shocks within relatively stable households, i.e. those that do not change from single to married or vice-versa within a six-year window. A more sophisticated version of this model, in which intra-household allocations are renegotiated over the course of a marriage, might be a promising framework for future research in the context of bilateral risk-sharing with limited commitment (see Ligon et al., 2002, and Mazzocco and Yamaguchi, 2007) and could be used to explore in more detail the role of marital sorting in providing access to insurance for different types of shocks and at different points in the life cycle.

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APPENDICES: NOT FOR PUBLICATION

# A Estimation of longitudinal effects of disability using the SLID

In this appendix, we describe in more detail our data source and empirical methodology. Information on the construction of our disability measure is in section A.1. The estimation methodology we use to investigate economic outcomes following disability onset is described in section A.2.

## A.1 Disability questions in the SLID

In the SLID, an individual is classified as disabled if he or she reports a limitation along any of the following dimensions: (1) easily completing one or more routine physical activities such as climbing stairs; (2) accomplishing required or desired activities 'at work' or 'at a job, business or school'; (3) accomplishing required or desired activities 'at home'; or (4) completing required or desired 'other activities' such as those associated with transportation or leisure. The questions about disability limitations 'at work' are asked of respondents or about subjects under 70 who worked in the reference year. The question about disability limitations 'at a job or business or at school' is asked of respondents under 70 who did not work in the previous year. In the longitudinal file, the responses to these questions are combined into a single variable reported for the entire sample population under age 70.

For the latter three types of limitation, individuals can respond that their were limited in the respective type of activity 'sometimes' or 'often'. Additional questions are asked of workers who report any type of disability: whether the condition made it difficult to change jobs or find a better job; and whether individuals wanted to work more or fewer hours due to their condition. Individuals who report a limitation but did not work in the previous year are additionally asked if their condition 'completely prevents' them from 'working at a job or business or looking for work'. Finally, individuals who report a current disability along at least one of the dimensions detailed above are asked about the duration of their condition: how many years they have had it and whether it was present at birth. In our analysis, men who report having their condition from birth or before age 19 are discarded from the sample.

## A.2 Responses to disability in the SLID: Empirical Methodology

A crucial advantage of the SLID is its relatively large cross-sectional dimension, which gives us the sample sizes needed to estimate post-onset changes in labor supply, participation and wages disaggregated by marital status. However, the large cross-section is compensated by a relatively short panel dimension, especially compared to U.S. income studies like the PSID. This sort panel dimension requires us to make two adjustments to our SLID sample before estimating equations (8) and (9). Because we are working with retrospective data on disabling conditions, we observe individuals at long ranges from the onset of their condition only if they report a current realization of their disability during the course of the survey (that is, only if the disability affects them in physical or economic activities in one of the $N \leq 6$ periods we observe them); otherwise they are not asked any retrospective questions about the duration of their condition.

In order to create a disability sample that is representative of the Canadian population, we use information from a second panel data set of Canadian households, the National Health and Population Survey, to create a post-onset sample in the SLID that reflects the entire Canadian post-onset population. The NPHS interviews individuals only biannually and contains limited information on labor supply and income. However, it has followed the same panel of individuals for six waves, or twelve years, as of 2010, with data available from 1994 to 2006. Taking individuals who report a new limiting condition in the first two waves of the NPHS, we can therefore construct ten-year panels and estimate the average $k \in \{1, 10\}$ post-onset reoccurrence of disability (the likelihood of reporting an active limitation) in every year $k$ following onset. We then re-weight the observed post-onset observations from the SLID to reflect the distribution of disability recurrence (active limitation) at every year following onset.

Second, we create a control group of individuals who are observed in the SLID for the first time either two or three years prior to onset. Since there is still potential for selection in the pre-onset group (i.e. some individuals observed prior to onset will only report limiting conditions post-onset and therefore would not be identified as disabled in the NPHS), we re-weight each observation for individuals between three and one years pre-onset based on the likelihood he or she would show up in the post-onset population based on pre-determined characteristics such as educational attainment, parents' education, region of residence and age, as well as interactions of these variables. The weight assigned to each individual in each pre-onset year group is the relative probability from a probit regression of being in the post-onset population on this set of pre-determined variables.

In the final step, as described in section 3, we estimate (8) and (9) using the sampling weights generated in the first step, and using as a control group all individuals first observed either two or three years prior to onset, with corresponding weights from the second step.

# B Optimal responses to disability shocks with a dynamic human capital motive

This section presents analytical predictions for labor supply following disability shocks when individuals face human capital considerations, as in section 4.1.

When we introduce a dynamic human capital function linking labor supply, disability and wages, the predicted level responses of hours worked to disability-induced changes in effective time are complicated by the effect of the shock on the incentive to accumulate, or prevent decumulation, of human capital. This effect works through two channels:

1. a reduction in human capital induced by a drop in labor supply following a shock lowers human resources, and hence consumption

2. a reduction in human capital induced by a drop in labor supply following a shock affects the likelihood of divorce and/or the pool of willing future marriage partners

To derive and interpret the analytical expressions, we maintain two assumptions: (1) $\frac{\partial H(n;w)}{\partial \delta}|n \equiv H_{\delta.}(\cdot)|n = 0$, i.e. there is no direct partial effect of disability on the evolution of wages so long as effective labor supply is held constant. This is consistent with our estimates of equation (16) reported in appendix C.2. (2) $\frac{\partial \varpi^f}{\partial w'_f} \equiv \varpi^f_{H^f} = \frac{\partial \varpi^f}{\partial w'} \equiv \varpi^f_H = 0$. This restriction implies that women are the main drivers of divorce, and that the likelihood of a man forcing a divorce is independent of his own wage. This assumption does not explicitly in the model, but is consistent with the fact that $\theta > \theta^f$ in SMM estimation of all our models.

We begin by deriving the first order conditions governing each partners' leisure for a married household. Again, the problem, and solution, for single men has exactly the same format, conditional on $w_f = \lambda = \xi_{2b} = \lambda = \xi_{3b} = \xi_{4b} = 0$ and $\xi_3 : q = q(a', w'; \delta_h, \delta_n)$.

$$(1-\lambda)u_l = \xi_1 \frac{w}{\delta_n} + [\xi_{3a}\varpi_H + \xi_{4a}]\frac{H_n(\cdot)}{\delta_n} \tag{18}$$

$$\lambda u^f_l = \xi_1 w_f + [\xi_{3a}\varpi_{H^f} + \xi_{4b}]H^f_n(\cdot) \tag{19}$$

Differentiation of (18) with respect to $\delta_n$ gives an expression for $\frac{\partial l}{\partial \delta_n}$ that can be decomposed into four components:

- $A = \left(-\xi_1 \frac{w}{\delta_n^2} - \xi_{3a}\varpi_H \frac{H_n(\cdot)}{\delta_n^2} - \xi_{4a}\frac{H_n(\cdot)}{\delta_n^2}\right)/\Delta > 0$ [substitution effect]
- $B_{\delta_n} = \left(\frac{\partial \xi_1}{\partial \delta_n}\frac{w}{\delta_n} + \frac{\partial \xi_{3a}}{\partial \delta_n}\varpi_H \frac{H_n}{\delta_n} + \frac{\partial \xi_{4a}}{\partial \delta_n}\frac{H_n}{\delta_n}\right)/\Delta \gtreqless 0$ [income effect]
- $C_{\delta_n} = \left((-\xi_{3a}\varpi_H - \xi_{4a})\frac{H_{nn}n}{\delta_n^2}\right)/\Delta < 0$ [HC time-less effect]
- $D_{\delta_n} = \left(\frac{H_n}{\delta_n}\xi_{3a}\varpi_{H\delta_n}\right)/\Delta \gtreqless 0$ [marital stability effect]

where $\Delta = (1-\lambda)u_{ll} + (\xi_{3a}\varpi_H + \xi_{4a})\frac{H_{nn}}{\delta_n^2} < 0$, $\varpi_H \equiv \frac{\partial \varpi}{\partial w'}$, and $\varpi_{H\delta} \equiv \frac{\partial^2 \varpi}{\partial w' \partial \delta}$.[44]

Differentiation of (19) with respect to $\delta_h$ gives an expression which can be decomposed in only three parts, as there is no substitution effect associated to $\delta_h$ shocks:

- $B_{\delta_h} = \left(\frac{\partial \xi_1}{\partial \delta_h}\frac{w}{\delta_n} + \frac{\partial \xi_{3a}}{\partial \delta_h}\varpi_H \frac{H_n}{\delta_n} + \frac{\partial \xi_{4a}}{\partial \delta_h}\frac{H_n}{\delta_n}\right)/\Delta \gtreqless 0$ [wealth effect]
- $C_{\delta_h} = \left((-\xi_{3a}\varpi_H - \xi_{4a})\frac{H_{nn}h}{\delta_n^2}\right)/\Delta < 0$ [HC time-loss effect]
- $D_{\delta_h} = \left(\frac{H_n}{\delta_n}\xi_{3a}\varpi_{H\delta_h}\right)/\Delta \gtreqless 0$ [marital stability effect]

The uncompensated response of leisure hours (denoted $\Omega$), for a husband facing $\delta_n$ (20) and $\delta_h$ (21) shocks are:

$$\Omega_{\delta_n} = A + B_{\delta_n} + C_{\delta_n} + D_{\delta_n} \tag{20}$$

$$\Omega_{\delta_h} = B_{\delta_h} + C_{\delta_h} + D_{\delta_h} \tag{21}$$

[44]Throughout, we also suppress the expectation operator on $H'$ and $w'$. We can think of individuals choosing some $\dot{H}'$ which is deterministic function of $n$ and $w$. Then, $H' = \dot{H}' + \nu'$.

Corresponding optimal responses of wives to either type of shock are simpler:

$$\Omega^f_\delta = \mathtt{B}_\delta + \mathtt{D}_{\delta.} \tag{22}$$

where

- $\mathtt{B}_\delta = \left( \frac{\partial \xi_1}{\partial \delta} w_f + \frac{\partial \xi_{3a}}{\partial \delta} \varpi_{H^f} H^f_n + \frac{\partial \xi_{4b}}{\partial \delta} H^f_n \right) / \Delta^f$ is the wealth effect;
- $\mathtt{D}_\delta = \left( H^f_n \xi_{3a} \varpi_{H^f \delta} \right) / \Delta^f$ is the marital stability effect.

and $\Delta^f = \lambda u_{ll} + (\xi_{3a}\varpi_{H^f} + \xi_{4b}) H^f_{nn}(\cdot) \gtreqless 0$ and $\varpi_{H^f \delta} \equiv \frac{\partial^2 \varpi}{\partial w'_f \partial \delta}$. Finally, we transform semi-elasticities of leisure $\Omega$ into semi-elasticities of labor $\mu$ (what we report in section 2) imposing the time-use constraint $\xi_{2a}$ for husbands and $\xi_{2b}$ for wives.

$$\mu_{\delta_n} = -\frac{\Omega_{\delta_n}}{\delta_n} - \frac{n}{\delta_n} \gtreqless 0 \qquad \mu_{\delta_h} = -\frac{\Omega_{\delta_h}}{\delta_n} - \frac{\overline{h}}{\delta_n} \gtreqless 0 \tag{23}$$

$$\mu^f_{\delta_n} = -\Omega^f_{\delta_n} \gtreqless 0 \qquad \mu^f_{\delta_h} = -\Omega^f_{\delta_h} \gtreqless 0 \tag{24}$$

Despite the messy algebra, interpretation of the above expressions is fairly straightforward and informative about the role played by human capital accumulation in the model. Compared to the $\mu_{\delta_n}$ defined in equation (5) from section 2, the substitution and wealth effects in the endogenous wage model are each augmented by two extra terms working through the binding human capital and divorce likelihood constraints. The substitution effect is strengthened by the fact that not only consumption but also future wage accumulation becomes relatively costly in terms of current-period resources. The wealth effect is affected by changes in the shadow values of the wage accumulation function and the (unknown) marital stability function. The intratemporal time-loss effect is unchanged. Of the two new terms, $C_\delta$—the 'human capital time-loss' effect—captures the fact that increases in $\delta$ decrease effective $n$ in human capital production with $l$ held constant, thereby increasing marginal return to $n$ since $H_{nn}(\cdot) < 0$ (see table 13), partially offsetting the negative substitution effect. $D_\delta$ captures the effect of $\delta$ on the contribution of $w'$ to marital stability.

Three features of the human-capital-augmented $\mu_\delta$s are worth describing in further detail:

1. The wealth effect of a $\delta$ shock, as defined above, can not be unambiguously signed as in the workhorse model. This is due to the fact that $\frac{\partial \xi_{4a}}{\partial \delta}$ may be positive or negative depending (mainly) on expectations about $\delta'$. For instance, if a disability shock is expected to be very persistent or 'chronic', the individual may expect to be driven to a corner solution for $l$ in all future periods, for example through early retirement. In this case, $\frac{\partial \xi_{4a}}{\partial \delta}$ will be negative. $\frac{\partial \xi_{4a}}{\partial \delta}$ is also likely to increase with age and decrease arithmetically in $w$ since low human capital decreases the attractiveness of remaining in the labor force while disabled. As a result, the augmented wealth effect may become smaller as a disability spell progresses or worsens, and as an individual ages, leading to gradual reductions in labor supply following onset.

2. The marital stability effect $D_{\delta_h}$ is also of unambiguous sign because it is not in general possible to sign $\varpi_{H\delta}$ (or $q_{H\delta}$ for singles). In the extreme case, if the disability is persistent and wives always divorce disabled husbands, then $\varpi_{H\delta}$ will be negative, inducing larger drops in labor supply (usually followed by changes in marital status). If on the other hand, the presence of disability induces divorce only when husbands don't work (because, for instance, the $\delta$ shocks also make husbands less useful in the home), then $\varpi_{H\delta} > 0$, leading to smaller reductions in labor supply following shocks. Since in this paper we study only relatively stable marriages, this effect helps explain the large role that human capital plays in (potentially) solving the 'puzzle' of married men's responses to disability.

3. Finally, the net effect of disability on the labor supply spouses is very ambiguous, as required to explain the lack of added worker effect in a world in which disability imposes serious costs on households. Note that for stable marriages (or in a model with exogenous marriage) the human capital-augmented optimal responses of spousal labor would be unambiguously positive, and larger than in the workhorse model. This is because the term $\frac{\partial \xi_{4b}}{\partial \delta}$ in $\mathtt{B}_\delta$ is unambiguously positive: the wife's human capital is more important to the household when her husband is limited by a disability.[45] When marriage is endogenous, however, the terms in $\mu_\delta^f$ relating to marital stability will generally work in the opposite direction, particularly if, as is intuitively likely, (1) the presence of disability raises the $\lambda$-weighted welfare cost of an endogenous separation ($\frac{\partial \xi_{3a}}{\partial \delta} > 0$); and (2) increases in the wife's wage make a separation more likely ($\varpi_{H^f} < 0$). With $\Delta_f > 0$, this effect is further reinforced ($\mathtt{D}_\delta$) if $\varpi_{H^f \delta} < 0$, meaning increases in spousal wages are more likely to induce a divorce when the husband is disabled. We note that this is especially likely to be the case when home production is endogenous, since there is limited potential for $\delta_h$-limited men to re-specialize in the home.

The previous discussion is intended to provide additional exposition of our model. We leave a more detailed study of marital stability and idiosyncratic risk to future work.

# C Methodological issues and supplemental estimates for the numerical model

In this section we discuss issues related to the measurement and estimation of the home production and human capital technologies in our extended model (Model E).

## C.1 Home production technology

We obtain the estimates reported in table 3 using a two stage approach. In the first stage, we estimate married men and women's inputs into housework–the left-hand side variables in equation (3)–as a function of their own, and their partner's, characteristics. These include age

[45] In the numerical implementation this is true since a man's disability benefit entitlements do not depend on the spouse's labor supply.

of both spouses and its square, years of education of both spouses and its square, number of children in the household, presence of children under six, self-reported health of both spouses, whether or not the individual receives help from relatives, whether or not the individual is Catholic, whether the individual or the spouse are union members, own and spousal race (white or non-white), individual and spousal wage and its square, and year dummies corresponding to the given wave. Instrumenting is necessary to deal with measurement error in reported housework which can arise from the fact that only one member of the couple reports housework hours for *both* himself and his spouse, as well as from potentially varying interpretations of the term 'housework' as defined in the questionnaire.

In the second stage, the (non-linear) estimating equation is a version of (15) except that the hats indicate that we are using fitted values from the first stage,

$$\dot{\bar{\mathtt{h}}}_f + \dot{\bar{\mathtt{h}}} = a_f \hat{\mathtt{h}}_f^{q_f} + a\hat{\mathtt{h}}^q \tag{25}$$

The dependent variables $\dot{\bar{\mathtt{h}}}_f + \dot{\bar{\mathtt{h}}}$ are the predicted amount of time that the partners would have to devote to housework in autarky. These values are estimated for single men and women in our PSID sample using the same set of regressors used to instrument for married hours of housework (omitting child indicators for single men, under the assumption that children live with their mothers in the event of divorce or widowhood).

The estimation sample includes all households in the 1999-2005 PSID panels for which at least one member does positive hours of housework, and total reported housework is less than 150 hours.

## C.2 Human capital technology

We estimate a process for human capital accumulation from the 1999-2007 longitudinal files of the SLID, specifically the six-year panels beginning in 1999 and 2002. We adopt a three-stage estimation process that controls for selection into the labor market and for the possible endogeneity of hours worked.

In the first stage, we run a selection equation and calculate inverse Mills ratios for the likelihood of observing a wage for all individual-year observations in the sample. We use as selection variables measures of the respondent's parents' education, indicators for a recent death in the family, and the presence in the respondent's household of children under six.

In the second stage, we use a heteroskedasticity-robust GMM estimator to estimate current wages as a function of lagged wages, lagged hours worked, age, education and other factors, according to equation (16). To control for the possible endogeneity of hours, we instrument for all terms involving lagged hours with the three-year lag of the same term as well as various demographic effects: household size, presence of a limiting disability (which is insignificant when included at the third stage), and controls for immigrant, visible minority and aboriginal status. Our sample for the second-stage regressions therefore consists of the last three observations for each individual in the 1999 and 2002 panels who is also observed three years earlier. At both stages of the estimation, we also control for cohort and age effects, region and urban effects, self-assessed health, full-time student status, the provincial minimum wage, occupation, marital status and (for women) number of children, all of which, unsurprisingly, we find may have direct effects on the wage, conditional on lagged hours and lagged wage. All instruments, and their individual-specific time averages, are also included in the first-stage selection equation. The main assumptions underlying our choice of instrumenting approach is that lagged hours are likely to be correlated with future choices of hours due either to the timing of reported hours, lagged hours and wage, or to anticipation of shocks near in the future (such as a factory closing). However, hours should be uncorrelated with iid error realizations far in the future. The additional demographic controls have no effect on hours outside determining levels of employment.[46] A Hansen J-test of the residuals from this third-stage regression fails to reject the validity of the instrument set.

Finally, in the last stage of the estimation we use our residuals to estimate the heterogeneity structure of $\nu$, which we allow to be heteroskedastic in age and $H$. Results from a linear regression of $\sigma_\nu^2$ on a cubic in age and lagged values of human capital $H$ are reported in the last two columns of table 13 below.

Table 13: Endogenous wage parameter estimates

| Parameters | | | Heterogeneity structure for $\sigma_\nu^2$ | | |
|---|---|---|---|---|---|
| | Male | Female | | Male | Female |
| $\alpha_{11}$ | 0.478 | 0.719 | $H$ | 0.527 | -0.013 |
| | (0.117) | (0.0737) | | (1.68) | (3.46) |
| $\alpha_{12}$ | 0.0277 | 0.0334 | $H^2$ | 0.00108 | -0.0288 |
| | (0.0213) | (0.0340) | | (0.0546) | (0.1290) |
| $\alpha_{21}$ | $6.05E^{-4}$ | $2.47E^{-4}$ | $H^3$ | $2.99E^{-4}$ | 0.0014 |
| | $(2.08E^{-4})$ | $(2.14E^{-4})$ | | $(4.90E^{-4})$ | (0.0013) |
| $\alpha_{22}$ | $-4.90E^{-6}$ | $-2.89E^{-6}$ | $age$ | 1.110 | -2.460 |
| | $(2.45E^{-6})$ | $(3.84E^{-6})$ | | (3.71) | (4.25) |
| $\alpha_{31}$ | $-3.95E^{-6}$ | $1.46E^{-6}$ | $age^2$ | -0.0577 | 0.0463 |
| | $(2.23E^{-6})$ | $(3.79E^{-6})$ | | (0.0865) | (0.104) |
| $\alpha_{32}$ | $1.14E^{-8}$ | $-4.74E^{-8}$ | $age^3$ | $6.36E^{-4}$ | $-2.72E^{-4}$ |
| | $(3.08E^{-8})$ | $(7.29E^{-8})$ | | $(6.51E^{-4})$ | $(8.06E^{-4})$ |
| | . | . | $intrcpt$ | 8.28 | 52.5 |
| | . | . | | (45.2) | (55.6) |
| $Adj.R-sq$ | 0.849 | 0.789 | | | |

Parameter vectors $\alpha_1$, $\alpha_2$ and $\alpha_3$ are each jointly significant for both men and women at the 1% level.

[46]For instance, discrimination based on visible minority status could affect an individual's likelihood of being hired and fired, but, conditional on his hours worked and previous wage realizations, has no additional effects on his predicted current wage.

Table 14: Average weekly hours worked following disability onset

| Year from onset | SLID | | Model WH | | Model E | | Model E-1 | | Model E-2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All men[a] | Dif[b] | All men | Dif | All men | Dif | All men | Dif | All men | Dif |
| -1 | 0.512 | −0.845 | 0.206 | −0.200 | 0.098 | −0.226 | 0.259 | −0.263 | 0.009 | −0.341 |
| | (0.547) | (1.468) | (0.242) | (0.504) | (0.252) | (0.640) | (0.208) | (0.625) | (0.271) | (0.545) |
| 0 | −1.78 | 1.739 | −4.603 | −0.931 | −1.692 | 0.533 | −1.713 | 0.072 | −3.996 | −0.258 |
| | (0.609) | (1.700) | (0.268) | (0.555) | (0.253) | (0.655) | (0.215) | (0.638) | (0.296) | (0.591) |
| 1 | −2.033 | 1.822 | −5.843 | −1.361 | −2.416 | 1.114 | −2.405 | 0.643 | −4.954 | −0.456 |
| | (0.662) | (1.881) | (0.322) | (0.668) | (0.297) | (0.772) | (0.253) | (0.753) | (0.348) | (0.700) |
| 2 | −3.084 | 1.432 | −5.363 | −1.416 | −2.575 | 1.373 | −2.614 | 0.585 | −4.616 | −0.500 |
| | (0.679) | (1.986) | (0.329) | (0.695) | (0.304) | (0.782) | (0.261) | (0.759) | (0.351) | (0.725) |
| 3 | −2.695 | 2.552 | −4.863 | −1.073 | −2.581 | 1.578 | −2.745 | 1.008 | −4.172 | −0.222 |
| | (0.714) | (2.106) | (0.351) | (0.739) | (0.331) | (0.846) | (0.288) | (0.835) | (0.373) | (0.776) |
| 4 | −2.474 | 2.636 | −4.259 | −1.325 | −2.599 | 1.884 | −2.873 | 1.471 | −3.624 | −0.443 |
| | (0.751) | (2.209) | (0.372) | (0.775) | (0.364) | (0.938) | (0.323) | (0.932) | (0.399) | (0.813) |
| 5 | −2.638 | 4.336 | −3.770 | −1.400 | −2.756 | 2.578 | −3.095 | 1.776 | −3.339 | −0.377 |
| | (0.801) | (2.344) | (0.415) | (0.847) | (0.427) | (1.091) | (0.379) | (1.077) | (0.451) | (0.915) |
| 6 | −3.328 | 6.090 | −3.511 | −1.355 | −2.799 | 2.353 | −3.200 | 1.838 | −3.140 | −0.303 |
| | (0.832) | (2.515) | (0.444) | (0.921) | (0.464) | (1.174) | (0.417) | (1.190) | (0.479) | (0.981) |
| 7 | −3.383 | 7.531 | −3.615 | −0.696 | −3.276 | 3.958 | −3.391 | 2.708 | −3.321 | 0.102 |
| | (0.892) | (2.729) | (0.459) | (0.975) | (0.494) | (1.267) | (0.437) | (1.288) | (0.503) | (1.057) |
| 8 | −3.268 | 8.910 | −3.417 | −0.864 | −3.324 | 3.967 | −3.427 | 2.889 | −3.253 | −0.100 |
| | (0.886) | (2.553) | (0.481) | (0.991) | (0.514) | (1.320) | (0.462) | (1.340) | (0.526) | (1.081) |
| 9 | −3.382 | 7.644 | −4.283 | −0.827 | −3.923 | 4.074 | −4.209 | 3.415 | −3.887 | −0.247 |
| | (0.893) | (2.547) | (0.527) | (1.086) | (0.556) | (1.396) | (0.506) | (1.430) | (0.578) | (1.191) |
| 10 | −4.323 | 9.039 | −4.971 | −0.666 | −4.678 | 4.994 | −4.735 | 3.774 | −4.451 | 0.263 |
| | (0.918) | (2.574) | (0.567) | (1.211) | (0.602) | (1.496) | (0.533) | (1.471) | (0.620) | (1.302) |

(a) Estimated difference in average weekly hours relative to the pre-onset control group for all men, by year from onset ($\dot{\delta}$) (b) Estimated difference-in-difference between married men and single men, by year from onset ($\overline{\delta}$)

Table 15: Annual participation rates following disability onset

| Year from onset | SLID | | Model WH | | Model E | | Model E-1 | | Model E-2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All men[a] | Dif[b] | All men | Dif | All men | Dif | All men | Dif | All men | Dif |
| -1 | 0.017 | −0.003 | 0.004 | −0.002 | 0.000 | −0.001 | 0.003 | 0.000 | 0.001 | −0.004 |
| | (0.007) | (0.025) | (0.005) | (0.011) | (0.006) | (0.014) | (0.004) | (0.013) | (0.006) | (0.013) |
| 0 | −0.012 | 0.018 | −0.182 | −0.098 | −0.017 | 0.039 | −0.014 | 0.029 | −0.165 | −0.067 |
| | (0.009) | (0.030) | (0.009) | (0.020) | (0.006) | (0.016) | (0.005) | (0.016) | (0.009) | (0.020) |
| 1 | −0.033 | 0.007 | −0.079 | −0.044 | −0.017 | 0.031 | −0.013 | 0.028 | −0.069 | −0.032 |
| | (0.009) | (0.032) | (0.007) | (0.016) | (0.007) | (0.017) | (0.005) | (0.017) | (0.008) | (0.016) |
| 2 | −0.044 | 0.022 | −0.100 | −0.046 | −0.023 | 0.040 | −0.021 | 0.031 | −0.088 | −0.015 |
| | (0.010) | (0.034) | (0.008) | (0.017) | (0.007) | (0.018) | (0.006) | (0.017) | (0.008) | (0.019) |
| 3 | −0.044 | 0.060 | −0.097 | −0.050 | −0.029 | 0.046 | −0.029 | 0.044 | −0.085 | −0.025 |
| | (0.010) | (0.037) | (0.008) | (0.018) | (0.008) | (0.019) | (0.006) | (0.019) | (0.009) | (0.019) |
| 4 | −0.047 | 0.060 | −0.088 | −0.049 | −0.034 | 0.057 | −0.033 | 0.048 | −0.080 | −0.025 |
| | (0.011) | (0.039) | (0.009) | (0.019) | (0.008) | (0.022) | (0.007) | (0.021) | (0.009) | (0.020) |
| 5 | −0.051 | 0.101 | −0.075 | −0.036 | −0.039 | 0.068 | −0.040 | 0.052 | −0.071 | −0.008 |
| | (0.011) | (0.042) | (0.009) | (0.020) | (0.010) | (0.025) | (0.008) | (0.024) | (0.010) | (0.023) |
| 6 | −0.060 | 0.139 | −0.076 | −0.032 | −0.040 | 0.066 | −0.048 | 0.059 | −0.073 | −0.009 |
| | (0.012) | (0.046) | (0.010) | (0.022) | (0.010) | (0.026) | (0.009) | (0.027) | (0.011) | (0.025) |
| 7 | −0.071 | 0.167 | −0.076 | −0.027 | −0.050 | 0.089 | −0.051 | 0.072 | −0.07 | −0.006 |
| | (0.013) | (0.048) | (0.010) | (0.024) | (0.011) | (0.029) | (0.010) | (0.030) | (0.012) | (0.026) |
| 8 | −0.069 | 0.192 | −0.075 | −0.027 | −0.049 | 0.097 | −0.055 | 0.085 | −0.070 | −0.002 |
| | (0.013) | (0.048) | (0.011) | (0.024) | (0.012) | (0.030) | (0.010) | (0.031) | (0.012) | (0.026) |
| 9 | −0.061 | 0.157 | −0.093 | −0.028 | −0.059 | 0.105 | −0.062 | 0.085 | −0.086 | −0.013 |
| | (0.013) | (0.046) | (0.012) | (0.027) | (0.013) | (0.033) | (0.011) | (0.033) | (0.014) | (0.029) |
| 10 | −0.089 | 0.190 | −0.101 | −0.029 | −0.076 | 0.133 | −0.068 | 0.092 | −0.096 | −0.006 |
| | (0.014) | (0.051) | (0.013) | (0.030) | (0.014) | (0.036) | (0.012) | (0.035) | (0.015) | (0.033) |

(a) Estimated difference in participation rate relative to the pre-onset control group for all men, by year from onset ($\dot{\delta}$) (b) Estimated difference-in-difference between married men and single men, by year from onset ($\bar{\delta}$)

Table 16: Average weekly hours and participation rates of wives following onset onset

| Year from | SLID | | Model WH | | Model E | | Model E-1 | | Model E-2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| onset | Hours[a] | Part[b] | Hours | Part | Hours | Part | Hours | Part | Hours | Part |
| -1 | −1.271 | 0.004 | −0.225 | −0.003 | −0.254 | −0.003 | −0.303 | −0.008 | −0.159 | −0.003 |
| | (0.674) | (0.016) | (0.352) | (0.008) | (0.455) | (0.011) | (0.416) | (0.011) | (0.416) | (0.009) |
| 0 | 0.120 | 0.008 | 0.083 | −0.005 | −0.643 | −0.004 | −0.111 | −0.007 | −0.290 | −0.003 |
| | (0.761) | (0.017) | (0.352) | (0.009) | (0.453) | (0.012) | (0.419) | (0.011) | (0.417) | (0.010) |
| 1 | −0.199 | 0.005 | 0.302 | −0.009 | −0.821 | −0.018 | 0.003 | −0.012 | −0.152 | −0.003 |
| | (0.821) | (0.019) | (0.400) | (0.010) | (0.520) | (0.013) | (0.479) | (0.013) | (0.478) | (0.011) |
| 2 | −0.115 | 0.005 | 0.200 | −0.002 | −0.830 | −0.011 | 0.058 | −0.004 | −0.079 | −0.001 |
| | (0.890) | (0.020) | (0.395) | (0.010) | (0.514) | (0.013) | (0.471) | (0.012) | (0.472) | (0.011) |
| 3 | −0.276 | −0.008 | 0.315 | −0.002 | −0.581 | −0.004 | 0.253 | 0.002 | 0.055 | −0.002 |
| | (0.942) | (0.021) | (0.415) | (0.010) | (0.536) | (0.014) | (0.492) | (0.013) | (0.497) | (0.011) |
| 4 | 0.003 | 0.010 | 0.353 | −0.002 | −0.346 | −0.003 | 0.378 | 0.001 | 0.094 | −0.003 |
| | (0.99) | (0.022) | (0.446) | (0.011) | (0.573) | (0.015) | (0.528) | (0.014) | (0.536) | (0.012) |
| 5 | 0.620 | 0.019 | 0.503 | 0.009 | −0.120 | 0.001 | 0.754 | 0.015 | 0.112 | 0.004 |
| | (1.043) | (0.022) | (0.503) | (0.012) | (0.646) | (0.016) | (0.591) | (0.015) | (0.604) | (0.014) |
| 6 | 0.617 | 0.013 | 0.392 | −0.002 | 0.114 | −0.003 | 0.922 | 0.013 | 0.102 | 0.003 |
| | (1.086) | (0.023) | (0.541) | (0.014) | (0.694) | (0.018) | (0.628) | (0.016) | (0.649) | (0.015) |
| 7 | 0.715 | 0.019 | 0.552 | 0.009 | 0.333 | 0.006 | 1.049 | 0.015 | 0.112 | 0.001 |
| | (1.119) | (0.024) | (0.555) | (0.014) | (0.710) | (0.018) | (0.643) | (0.017) | (0.669) | (0.016) |
| 8 | −0.014 | −0.012 | 0.655 | 0.004 | 0.247 | −0.001 | 1.138 | 0.006 | 0.111 | −0.001 |
| | (1.274) | (0.027) | (0.586) | (0.015) | (0.738) | (0.019) | (0.672) | (0.018) | (0.698) | (0.016) |
| 9 | 0.669 | −0.005 | 0.969 | 0.012 | 0.253 | 0.004 | 1.234 | 0.013 | 0.206 | −0.007 |
| | (1.444) | (0.030) | (0.611) | (0.015) | (0.765) | (0.020) | (0.701) | (0.018) | (0.734) | (0.018) |
| 10 | −1.168 | −0.026 | 0.842 | 0.008 | 0.232 | 0.006 | 1.318 | 0.013 | 0.090 | −0.006 |
| | (1.599) | (0.034) | (0.651) | (0.016) | (0.802) | (0.021) | (0.739) | (0.019) | (0.776) | (0.019) |

(a) Estimated difference in average weekly hours relative to the pre-onset control group for wives, by year from husband's disability onset
(b) Estimated difference in annual participation rate relative to the pre-onset control group for wives, by year from husband's disability onset

Table 17: *log* wages (selection-controled) following disability onset

| Year from | SLID I | | SLID 2 | | Model WH | | Model E | | Model E-1 | |
|---|---|---|---|---|---|---|---|---|---|---|
| onset | Single[a] | Married[b] | Single | Married | Single | Married | Single | Married | Single | Married |
| -1 | −0.020 | −0.005 | −0.029 | −0.006 | 0.007 | 0.003 | 0.015 | 0.003 | 0.020 | 0.006 |
| | (0.046) | (0.018) | (0.051) | (0.020) | (0.027) | (0.014) | (0.028) | (0.015) | (0.030) | (0.014) |
| 0 | −0.043 | −0.002 | −0.053 | 0.001 | 0.007 | −0.004 | 0.010 | 0.009 | 0.022 | 0.006 |
| | (0.044) | (0.017) | (0.049) | (0.019) | (0.026) | (0.014) | (0.028) | (0.015) | (0.030) | (0.014) |
| 1 | | | | | 0.000 | −0.007 | 0.000 | 0.006 | 0.009 | 0.005 |
| | | | | | (0.030) | (0.016) | (0.032) | (0.017) | (0.033) | (0.016) |
| 2 | −0.051 | −0.009 | −0.082 | −0.007 | 0.002 | −0.004 | −0.023 | −0.004 | −0.003 | −0.009 |
| | (0.042) | (0.016) | (0.046) | (0.017) | (0.030) | (0.016) | (0.032) | (0.017) | (0.033) | (0.016) |
| 3 | | | | | 0.005 | −0.003 | −0.035 | −0.013 | −0.030 | −0.018 |
| | | | | | (0.031) | (0.016) | (0.034) | (0.019) | (0.035) | (0.017) |
| 4 | −0.103 | −0.007 | −0.176 | −0.006 | 0.000 | −0.005 | −0.068 | −0.021 | −0.068 | −0.032 |
| | (0.046) | (0.017) | (0.055) | (0.018) | (0.034) | (0.018) | (0.037) | (0.020) | (0.039) | (0.018) |
| 5 | | | | | −0.004 | −0.006 | −0.099 | −0.037 | −0.099 | −0.055 |
| | | | | | (0.039) | (0.020) | (0.043) | (0.024) | (0.045) | (0.022) |
| 6 | −0.148 | −0.004 | −0.228 | 0.002 | −0.014 | 0.006 | −0.118 | −0.034 | −0.123 | −0.056 |
| | (0.060) | (0.018) | (0.071) | (0.020) | (0.041) | (0.022) | (0.045) | (0.026) | (0.047) | (0.024) |
| 7 | | | | | −0.012 | 0.014 | −0.163 | −0.036 | −0.159 | −0.054 |
| | | | | | (0.044) | (0.022) | (0.048) | (0.027) | (0.051) | (0.024) |
| 8 | −0.057 | 0.015 | −0.189 | 0.029 | 0.013 | 0.015 | −0.160 | −0.032 | −0.158 | −0.058 |
| | (0.059) | (0.019) | (0.080) | (0.021) | (0.045) | (0.023) | (0.049) | (0.028) | (0.052) | (0.026) |
| 9 | | | | | −0.003 | 0.007 | −0.185 | −0.050 | −0.194 | −0.078 |
| | | | | | (0.046) | (0.024) | (0.051) | (0.030) | (0.054) | (0.027) |
| 10 | −0.106 | 0.010 | −0.259 | −0.009 | −0.017 | 0.003 | −0.205 | −0.063 | −0.215 | −0.086 |
| | (0.063) | (0.020) | (0.099) | (0.029) | (0.050) | (0.026) | (0.053) | (0.032) | (0.055) | (0.029) |

(a) Estimated difference in mean log wages relative to the pre-onset control group for single men, by year from onset ($\dot{\delta}$); (b) Estimated difference in mean log wages relative to the pre-onset control group for married men, by year from onset ($\dot{\delta}$); (c) Results from model E-2 are omitted for space since wage patterns following disability are indistinguishable from those in model WH.

Table 18: *log* wages of workers (non-selection-adjusted) following disability onset

| Year from onset | SLID | | Model WH | | Model E | | Model E-1 | | Model E-2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All men[a] | Dif[b] | All men | Dif | All men | Dif | All men | Dif | All men | Dif |
| -1 | −0.019 | −0.012 | 0.005 | 0.002 | 0.012 | 0.004 | 0.019 | 0.004 | −0.004 | 0.005 |
| | (0.033) | (0.014) | (0.026) | (0.014) | (0.026) | (0.013) | (0.028) | (0.013) | (0.027) | (0.013) |
| 0 | 0.011 | 0.007 | 0.029 | 0.064 | 0.044 | 0.014 | 0.045 | 0.011 | 0.028 | 0.062 |
| | (0.036) | (0.016) | (0.027) | (0.015) | (0.026) | (0.013) | (0.028) | (0.013) | (0.028) | (0.015) |
| 1 | 0.006 | −0.002 | 0.006 | 0.016 | 0.029 | 0.011 | 0.031 | 0.009 | 0.001 | 0.018 |
| | (0.043) | (0.017) | (0.030) | (0.017) | (0.031) | (0.014) | (0.032) | (0.015) | (0.031) | (0.016) |
| 2 | 0.006 | 0.009 | 0.018 | 0.025 | 0.015 | 0.006 | 0.023 | −0.001 | 0.020 | 0.021 |
| | (0.045) | (0.019) | (0.030) | (0.017) | (0.031) | (0.014) | (0.032) | (0.015) | (0.031) | (0.016) |
| 3 | −0.052 | 0.011 | 0.023 | 0.024 | 0.017 | 0.003 | 0.015 | −0.004 | 0.023 | 0.024 |
| | (0.051) | (0.020) | (0.032) | (0.018) | (0.032) | (0.015) | (0.034) | (0.015) | (0.032) | (0.017) |
| 4 | −0.039 | 0.004 | 0.013 | 0.021 | −0.007 | −0.001 | −0.018 | −0.011 | 0.012 | 0.023 |
| | (0.053) | (0.022) | (0.034) | (0.019) | (0.036) | (0.016) | (0.038) | (0.017) | (0.035) | (0.018) |
| 5 | −0.033 | 0.021 | −0.001 | 0.013 | −0.023 | −0.012 | −0.045 | −0.020 | −0.006 | 0.022 |
| | (0.056) | (0.022) | (0.04) | (0.021) | (0.042) | (0.019) | (0.045) | (0.019) | (0.041) | (0.020) |
| 6 | −0.031 | 0.012 | −0.002 | 0.028 | −0.042 | −0.004 | −0.057 | −0.013 | −0.006 | 0.039 |
| | (0.058) | (0.023) | (0.042) | (0.023) | (0.045) | (0.021) | (0.048) | (0.021) | (0.043) | (0.022) |
| 7 | −0.019 | 0.031 | 0.003 | 0.038 | −0.075 | −0.001 | −0.084 | −0.013 | 0.001 | 0.046 |
| | (0.064) | (0.023) | (0.045) | (0.024) | (0.050) | (0.021) | (0.053) | (0.022) | (0.045) | (0.023) |
| 8 | 0.100 | 0.026 | 0.021 | 0.034 | −0.056 | −0.001 | −0.065 | −0.014 | 0.021 | 0.038 |
| | (0.057) | (0.024) | (0.048) | (0.025) | (0.051) | (0.022) | (0.055) | (0.022) | (0.049) | (0.024) |
| 9 | 0.022 | 0.022 | 0.016 | 0.028 | −0.072 | −0.016 | −0.113 | −0.024 | 0.006 | 0.038 |
| | (0.063) | (0.025) | (0.049) | (0.027) | (0.054) | (0.024) | (0.060) | (0.024) | (0.050) | (0.025) |
| 10 | −0.056 | 0.016 | 0.011 | 0.032 | −0.058 | −0.013 | −0.125 | −0.031 | 0.037 | 0.034 |
| | (0.063) | (0.025) | (0.053) | (0.028) | (0.057) | (0.024) | (0.062) | (0.025) | (0.052) | (0.027) |

(a) Estimated difference in mean log wages relative to the pre-onset control group for single male workers; (b) Estimated difference in mean log wage relative to the pre-onset control group for single male workers

Table 19: Labor, participation and wage results following disability onset: Model E-3

| Year from onset | Mens' wkly hrs | | Mens' annual part | | Wives | | Wages (Sel-adj) | | Wages (Workers) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All men[a] | Dif[b] | All men[c] | Dif[d] | Hours[e] | Part[f] | Single[g] | Married[h] | Single[i] | Married[j] |
| -1 | 0.040 | −0.002 | 0.001 | −0.002 | −0.314 | −0.008 | 0.006 | 0.005 | 0.003 | 0.007 |
| | (0.309) | (0.759) | (0.007) | (0.016) | (0.449) | (0.012) | (0.032) | (0.017) | (0.030) | (0.013) |
| 0 | −1.493 | 0.222 | −0.022 | 0.043 | −0.546 | 0.002 | 0.013 | 0.012 | 0.059 | 0.021 |
| | (0.31) | (0.757) | (0.008) | (0.019) | (0.445) | (0.011) | (0.032) | (0.017) | (0.030) | (0.013) |
| 1 | −2.143 | 0.318 | −0.021 | 0.021 | −0.317 | −0.007 | 0.023 | 0.001 | 0.047 | 0.013 |
| | (0.357) | (0.859) | (0.008) | (0.019) | (0.504) | (0.013) | (0.036) | (0.019) | (0.035) | (0.015) |
| 2 | −2.444 | 1.164 | −0.033 | 0.046 | −0.364 | 0.000 | −0.006 | −0.005 | 0.043 | 0.016 |
| | (0.367) | (0.894) | (0.009) | (0.020) | (0.500) | (0.013) | (0.036) | (0.019) | (0.035) | (0.015) |
| 3 | −2.509 | 1.961 | −0.038 | 0.063 | −0.170 | 0.002 | −0.033 | −0.010 | 0.031 | 0.016 |
| | (0.394) | (0.959) | (0.009) | (0.022) | (0.524) | (0.014) | (0.038) | (0.021) | (0.037) | (0.016) |
| 4 | −2.657 | 2.528 | −0.042 | 0.067 | −0.024 | 0.002 | −0.068 | −0.017 | 0.011 | 0.012 |
| | (0.434) | (1.049) | (0.010) | (0.024) | (0.564) | (0.015) | (0.041) | (0.023) | (0.041) | (0.017) |
| 5 | −2.714 | 3.397 | −0.041 | 0.071 | 0.006 | 0.010 | −0.109 | −0.017 | −0.039 | 0.012 |
| | (0.499) | (1.186) | (0.011) | (0.026) | (0.637) | (0.016) | (0.047) | (0.026) | (0.049) | (0.020) |
| 6 | −2.498 | 3.690 | −0.043 | 0.080 | 0.286 | 0.012 | −0.130 | −0.004 | −0.053 | 0.031 |
| | (0.533) | (1.252) | (0.012) | (0.028) | (0.681) | (0.018) | (0.049) | (0.029) | (0.052) | (0.021) |
| 7 | −2.725 | 4.726 | −0.043 | 0.097 | 0.637 | 0.013 | −0.153 | 0.000 | −0.064 | 0.030 |
| | (0.560) | (1.319) | (0.013) | (0.029) | (0.699) | (0.018) | (0.051) | (0.030) | (0.055) | (0.022) |
| 8 | −2.784 | 5.249 | −0.046 | 0.124 | 0.510 | 0.019 | −0.160 | 0.007 | −0.039 | 0.025 |
| | (0.585) | (1.385) | (0.013) | (0.031) | (0.737) | (0.019) | (0.054) | (0.031) | (0.058) | (0.023) |
| 9 | −3.554 | 6.113 | −0.064 | 0.138 | 0.596 | 0.021 | −0.204 | −0.010 | −0.059 | 0.014 |
| | (0.636) | (1.495) | (0.015) | (0.034) | (0.752) | (0.020) | (0.056) | (0.033) | (0.061) | (0.025) |
| 10 | −4.656 | 6.735 | −0.089 | 0.162 | 0.240 | 0.008 | −0.232 | −0.029 | −0.046 | 0.021 |
| | (0.695) | (1.594) | (0.016) | (0.038) | (0.801) | (0.022) | (0.058) | (0.036) | (0.064) | (0.027) |

(a) Estimated difference in average weekly hours relative to the pre-onset control group for all men, by year from onset; (b) Estimated difference-in-difference between married men and single men, by year from onset; (c) Estimated difference in participation rate relative to the pre-onset control group for all men, by year from onset; (d) Estimated difference-in-difference between married men and single men, by year from onset; (e) Estimated difference in average weekly hours relative to the pre-onset control group for wives, by year from husband's disability onset; (f) Estimated difference in annual participation rate relative to the pre-onset control group for wives, by year from husband's disability onset; (g) Estimated difference in mean log wages relative to the pre-onset control group for single men, by year from onset; (h) Estimated difference in mean log wages relative to the pre-onset control group for married men, by year from onset; (i) Estimated difference in mean log wages relative to the pre-onset control group for single male workers, by year from onset; (j) Estimated difference in mean log wage relative to the pre-onset control group for single male workers, by year from onset

Table 20: Labor, participation and wage results following disability onset: Model E-4

| Year from | Mens' wkly hrs | | Mens' annual part | | Wives | | Wages (Sel-adj) | | Wages (Workers) | |
|---|---|---|---|---|---|---|---|---|---|---|
| onset | All men[a] | Dif[b] | All men[c] | Dif[d] | Hours[e] | Part[f] | Single[g] | Married[h] | Single[i] | Married[j] |
| -1 | 0.062 | 0.064 | 0.000 | 0.001 | −0.270 | −0.008 | 0.000 | 0.003 | −0.001 | 0.006 |
| | (0.289) | (0.724) | (0.001) | (0.016) | (0.452) | (0.012) | (0.031) | (0.016) | (0.029) | (0.013) |
| 0 | −1.532 | 0.588 | −0.020 | 0.053 | −0.408 | 0.000 | 0.006 | 0.004 | 0.054 | 0.009 |
| | (0.289) | (0.728) | (0.053) | (0.018) | (0.449) | (0.012) | (0.031) | (0.016) | (0.029) | (0.013) |
| 1 | −2.186 | 0.872 | −0.020 | 0.037 | −0.222 | −0.008 | 0.004 | −0.006 | 0.043 | 0.003 |
| | (0.337) | (0.843) | (0.037) | (0.019) | (0.509) | (0.013) | (0.035) | (0.019) | (0.033) | (0.015) |
| 2 | −2.382 | 1.144 | −0.029 | 0.048 | −0.307 | 0.002 | −0.015 | −0.010 | 0.034 | 0.004 |
| | (0.344) | (0.862) | (0.048) | (0.020) | (0.504) | (0.013) | (0.035) | (0.019) | (0.034) | (0.015) |
| 3 | −2.356 | 1.702 | −0.034 | 0.059 | −0.085 | 0.002 | −0.038 | −0.013 | 0.025 | 0.006 |
| | (0.371) | (0.925) | (0.059) | (0.021) | (0.528) | (0.014) | (0.037) | (0.020) | (0.036) | (0.016) |
| 4 | −2.593 | 2.481 | −0.040 | 0.067 | 0.057 | 0.003 | −0.076 | −0.017 | 0.001 | 0.006 |
| | (0.411) | (1.018) | (0.067) | (0.023) | (0.567) | (0.015) | (0.040) | (0.022) | (0.040) | (0.017) |
| 5 | −2.671 | 3.348 | −0.037 | 0.071 | 0.215 | 0.011 | −0.120 | −0.021 | −0.048 | 0.002 |
| | (0.474) | (1.161) | (0.071) | (0.026) | (0.636) | (0.016) | (0.047) | (0.025) | (0.048) | (0.019) |
| 6 | −2.450 | 3.109 | −0.039 | 0.073 | 0.331 | 0.014 | −0.143 | −0.008 | −0.067 | 0.026 |
| | (0.506) | (1.216) | (0.073) | (0.027) | (0.681) | (0.017) | (0.049) | (0.028) | (0.051) | (0.021) |
| 7 | −2.736 | 4.288 | −0.043 | 0.094 | 0.666 | 0.012 | −0.169 | −0.005 | −0.07 | 0.025 |
| | (0.529) | (1.295) | (0.094) | (0.029) | (0.699) | (0.018) | (0.051) | (0.029) | (0.055) | (0.022) |
| 8 | −2.921 | 5.008 | −0.047 | 0.114 | 0.643 | 0.011 | −0.186 | 0.001 | −0.078 | 0.028 |
| | (0.558) | (1.377) | (0.114) | (0.032) | (0.733) | (0.019) | (0.055) | (0.030) | (0.058) | (0.022) |
| 9 | −3.466 | 5.690 | −0.061 | 0.139 | 0.847 | 0.025 | −0.211 | −0.014 | −0.070 | 0.017 |
| | (0.604) | (1.485) | (0.139) | (0.035) | (0.747) | (0.019) | (0.056) | (0.032) | (0.060) | (0.024) |
| 10 | −4.389 | 6.053 | −0.082 | 0.149 | 0.688 | 0.021 | −0.225 | −0.036 | −0.071 | 0.023 |
| | (0.659) | (1.564) | (0.149) | (0.037) | (0.783) | (0.020) | (0.057) | (0.036) | (0.064) | (0.026) |

(a) Estimated difference in average weekly hours relative to the pre-onset control group for all men, by year from onset; (b) Estimated difference-in-difference between married men and single men, by year from onset; (c) Estimated difference in participation rate relative to the pre-onset control group for all men, by year from onset; (d) Estimated difference-in-difference between married men and single men, by year from onset; (e) Estimated difference in average weekly hours relative to the pre-onset control group for wives, by year from husband's disability onset; (f) Estimated difference in annual participation rate relative to the pre-onset control group for wives, by year from husband's disability onset; (g) Estimated difference in mean log wages relative to the pre-onset control group for single men, by year from onset; (h) Estimated difference in mean log wages relative to the pre-onset control group for married men, by year from onset; (i) Estimated difference in mean log wages relative to the pre-onset control group for single male workers, by year from onset; (j) Estimated difference in mean log wage relative to the pre-onset control group for single male workers, by year from onset