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HEALTH STATUS AND THE ALLOCATION OF TIME

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SUMMARY

We consider the relationship between health and time allocation in the American Time Use Survey. Better health is associated with large positive effects on home production and larger positive effects on market production, but less consumption of leisure. Theoretically, if market- and home-produced goods are perfect substitutes, the positive correlation between health and home production implies that health exerts larger effects on home than on market efficiency. Notably, these correlations are higher for single people than for married people, perhaps reflecting a lack of market substitutes for the time of married people. Copyright © 2011 John Wiley & Sons, Ltd.

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1. INTRODUCTION

Despite recent advances investigating the economic consequences of health status, researchers know surprisingly little about how health impacts time allocation and, particularly, home production. This is an important subject as time use is a critical, yet understudied, component of welfare. In this paper, we fill this void by elucidating how health impacts time allocation.

This can happen through two channels. First, health affects market efficiency. If healthier people are more productive on the market, then they will receive higher remuneration *ceterus paribus* and, thus, work more through a standard substitution effect. Second, health impacts non-market efficiency. If healthier people are better at carrying out household duties, such as cooking, cleaning, or home improvements, then the costs of producing these goods at home will be lower, all else equal, and healthier people will devote more time to home production.

The strategy that we adopt to investigate these effects is as follows. First, to provide us with a loose structure, we construct a simple model of health and time allocation based on Gronau (1980). Second, we analyze data from the American Time Use Survey (ATUS). Owing to a dearth of convincing exogenous sources of variation in health status, the approach that we adopt here is very descriptive. We conduct simple exercises in which we look at how time allocations vary with age and health by gender and marital status while controlling for common confounding variables. We then use these estimated partial correlations in conjunction with comparative statics from our model to make inferences on the relative effects of health on market and non-market efficiency.

Our findings indicate that better health is correlated with more time allocated to productive activities and less time to various types of leisure. These correlations are larger for market than for non-market

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production. If market- and home-produced goods are highly substitutable (which is not an unreasonable assumption), then the positive correlation between health and home production implies that health exerts larger effects on non-market than on market efficiency. Interestingly, we show that most of the relationship between health and home production for single people occurs at the intensive margin, whereas the reverse is true for couples. This suggests that, for married people, time allocated to home production is somewhat inelastic with respect to their own health, unless they are sufficiently unhealthy in which case they do not work at all. Finally and in the spirit of this previous result, we show that the correlations between health and home production are larger for singles than for couples, which may reflect a lack of market substitutes for the time of married people.

Our investigation fits comfortably into a large literature that considers health as a critical determinant of economic behavior. For one, it has long been recognized that disease or disability can impede a person's capacity to work. Investigations into this theme have been made by Bound (1991), Rust and Phelan (1997), and French (2005) who looked into health and retirement behavior; Coile (2004) and Wu (2003) who considered the effects of own health status on spousal labor supply; and Smith (1999) who considered the problem more generally in a survey piece on health and socioeconomic status. Recently, the reach of health status has extended beyond labor supply, particularly to the issues of savings and portfolio choice. For example, Palumbo (2003) investigated the extent to which uncertain medical expenditures may induce agents to save more as a precaution against future medical costs and Rosen and Wu (2004) looked at the potential for poor health to affect people' subjective life expectancies and, thus, create incentives to hold less risky portfolios.

Our paper also fits into a large literature on the determinants of time allocations. While this literature is too large to summarize here, there are two papers that we would like to highlight. The first is Biddle and Hamermesh (1990) who investigate the economic determinants of sleeping time. They show that higher wages and more human capital reduce sleeping time. What is paradoxical about this is that higher wages and more human capital tend to be associated with better health, yet sleep is an input into the production of health. Mullahy and Robert (2010) provide a resolution to this puzzle by showing that, while more educated people sleep less, they also exercise more. The importance of these two findings for our work is that they show quite clearly how time allocation can affect health and, thus, highlight a limitation of our analysis.[1] Future work might want to address this within the context of a structural model, although identifying its parameters in a convincing manner (i.e. without leaning too heavily on distributional assumptions) might prove to be difficult.[2]

The balance of this paper is organized as follows. In the next section, we set-up a simple model of health and time allocation. In the remaining sections, we discuss our data source, present our results, and finish with concluding remarks.

2. HEALTH AND PRODUCTIVITY: THEORY

To fix ideas, we consider the productivity effects of health within the framework of Gronau (1980). An individual derives utility from three goods: a market good (x), a home-produced good (h), and leisure (l). Preferences over these goods are given by $u(x,h)+v(l)$. We denote health status by H and allow it to affect market productivity ($w(H)$) and non-market productivity ($A(H)$). Labor is allocated to

[1]For example, Bird and Freemont (1991) and MacDonald *et al.* (2005) both consider how time use affects well-being, although these papers are also descriptive.

[2]We are highly skeptical that regression discontinuity or instrument variables (not in the sense of the Cowles Foundation's original conception of them but in the sense that they are used in recent applications in which IV mimics a randomized trial as discussed in Deaton (2010)) would be useful here. First, as we have already stated, we think that convincing exogenous sources of variation in health are very elusive. Second, because these techniques are designed to essentially mimic randomization in observational data and, thus, are used to estimate treatment effects (in a very local sense), they are useful for dealing with omitted variables, but not reverse causality.

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the market (n) and to the home (m). Goods are produced at home with the technology $A(H)f(m)$. If we normalize the endowment of time to unity, the maximization program becomes

$$\max_{l,m,n} \; u(w(H)n, A(H)f(m)) + v(l) \quad \text{st } l+n+m = 1. \tag{1}$$

We assume that all production and utility functions are increasing and concave.

If market and home-produced goods are perfectly substitutable as in Gronau, then we can write $u(x, h) = \tilde{u}(c)$ where $c \equiv x+h$. In this case, the agent will allocate a positive amount of labor to the home according to the rule

$$m > 0 \Leftrightarrow A(H)f'(0) > w(H) \tag{2}$$

and, if the agent is not at a corner solution, home production will be pinned down by the condition

$$A(H)f'(m) = w(H) \tag{3}$$

At an interior solution, differentiating this condition with respect to H yields

$$\frac{\partial m}{\partial H} = \frac{w'(H) - A'(H)f'(m)}{A(H)f(m)} \tag{4}$$

which says healthier people will work more (less) at home if health has larger (smaller) impacts on non-market than on market productivity.

Next, the agent will sell a positive amount of his labor to the market according to the rule

$$n > 0 \Leftrightarrow w(H) > \frac{v'(1-m)}{u'(A(H)f(m))} \tag{5}$$

and, if the agent is at an interior solution, their market labor supply will be determined by

$$u'(w(H)n + A(H)f(m))w(H) = v'(1-n-m). \tag{6}$$

This is standard and says that the marginal rate of substitution between leisure and goods must equal the wage. At an interior solution, differentiating this condition obtains

$$\frac{\partial n}{\partial H} = \frac{-u''(c)w(H)\left[w'(H)n + A'(H)f(m) + A(H)f'(m)\frac{\partial m}{\partial H}\right] - v''(l)\frac{\partial m}{\partial H} - u'(c)w'(H)}{u''(c)w(H)^2 + v(l)} \tag{7}$$

This is a more complicated comparative static. The denominator is unambiguously negative. If $\partial m/\partial H > 0$, then the first and second terms in the numerator are positive, whereas the third term is negative. Accordingly, even if the non-market effects of health status dominate their market effects so that healthier people work more at home, it is still possible to observe that healthier people also work more on the market provided that the market effects of health are sufficiently strong. The utility of this simple structure is that if we estimate partial correlations from the data and analyze them in conjunction with the comparative statics from the model, we are able to make inferences about the relative effects of health on market and non-market efficiency.[3]

[3]There are key differences between this model and the canonical model of health investment discussed in Grossman (1972). In that model, time allocation also plays a crucial role. There is a construct called 'sick time' that is essentially a black hole that encroaches upon a person's stock of time that can be allocated to either leisure or production. Importantly, health does not impact productivity. It is precisely this that differentiates Grossman's model of health capital from other models of human capital (e.g. Ben-Porath (1967) and Becker (1964)). We chose the latter due to the fact that health affects prices in these models which yields cleaner predictions. In a model of health capital, better health simply relaxes the time constraint which is essentially an income effect. This tends to yield predictions that are less stark since goods can be either inferior or normal. Finally, we would like to point out that one of the drawbacks of using sick time from the standpoint of structural modelers is that it has no obvious measure in time use data. What would be classified as sick time in Grossman's model, gets classified as some form of leisure in time use data, thus, making it unclear how to differentiate between the two empirically.

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3. DATA DESCRIPTION

Our data source is the ATUS.[4] For the years 2006–2008, the ATUS has an Eating and Health Module with a question about the respondent's general health status. The data contain about 37 300 people. About 19 700 are married or cohabiting (9300 male, 10 400 female), and 17 700 are single (7000 male and 10 700 female). These sample sizes are slightly reduced in some of our regressions due to missing data. The ATUS uses a diary to measure time use in which people list their activities over a 24 h period.[5] These activities are placed into categories which are then used to construct time use variables. Activities which could not be easily categorized are assigned to unclassified time. We partition total time allocation into 10 categories: home work, paid work, sleep, sleeplessness, watching TV, leisure excluding TV watching, exercise, grooming and personal health care, other time, and unclassified time. We describe the activities that constitute each category in Table I. Descriptive statistics are provided in Table II. Note that all time use categories sum to 1440 min, the total number of minutes in a day. All extracts were created using the ATUS Extract Builder provided by the Maryland Population Research Center and all ATUS data are weighted by the Eating and Health Module weights.

We also use variables for health status, race, education, age, and presence of children in the household. Descriptive statistics for these are reported in Table II. Our health variable is a self-reported health status variable (SRHS) in which respondents categorize their own health into one of five categories: poor (SRHS = 5), fair (SRHS = 4), good (SRHS = 3), very good (SRHS = 2), or excellent (SRHS = 1). For the balance of this paper, we define 'good health' to be SRHS equal to 1 or 2 and 'bad health' to be SRHS to be equal to 4 or 5.

The SRHS variable plays a very prominent role in our analysis, so some words should be mentioned regarding its merits and demerits. On the pro side, while SRHS is subjective, it has consistently been shown to be highly correlated with morbidity and highly predictive of mortality in the PSID as shown in Halliday (2010) and Smith (2003). On the con side, the SRHS measure can be criticized precisely because it is subjective. However, Baker *et al*. (2004) have compared self-reported measures of objective health outcomes, a common alternative to SRHS, to the same objective health outcomes obtained from medical records and found that the self-reported objective measures contain measurement errors that are correlated with labor market participation. Based on this, it is not clear that these alternative health measures (even if they were available in the ATUS) would be preferred in an analysis of the relationship between health and labor supply.

4. EMPIRICAL RESULTS

We now turn to our empirical analysis. We report the results of OLS, Tobit, and Probit regressions from the ATUS. All regression estimations are conducted separately for married and single people broken down by gender and include dummy variables for good (SRHS equal to one or two) and bad health (SRHS equal to four or five) and a comprehensive set of control variables which are listed in the footnotes of the tables.

[4]Time use surveys have become quite prominent in the social sciences. For example, Biddle and Hamermesh (1990) have investigated sleeping; Mullahy and Robert (2010) have investigated sleeping and exercise; Hamermesh (2010) has investigated eating; Hallberg and Klevmarken (2003) have investigated child rearing; Prowse (2009) has made methodological contributions by devising ways of structurally estimating time use models.

[5]The ATUS measures time use in a particular day. Given this, as in Prowse (2009), our results correspond to a typical day of the year. There are some that would argue that a zero in the ATUS could be measurement error because some activities occur infrequently and so, even if they do not occur in a given day, they may occur at some point over the course of a year. However, this critique misses the point which is that the survey is designed to measure time use on a typical day, not over the course of an entire year. Moreover, the survey measures time use on all 7 days of the week and weights are employed to back out partial correlations that are representative of a typical day.

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Table I. Description of time use variables in ATUS

	Time uses
Home work	Meal preparation and cleanup
	House cleaning
	Laundry
	Shopping
	Home repair and maintenance
	Gardening
	Pet care
	Household management/bookkeeping
	Vehicle care
	Child and adult care of household members
	Appliance care
	Sewing
	Related travel to all
Paid work	Work at a paid job
	Waiting, socializing, eating associated with working
	Other income-generating activities
	Job search and interviewing
Sleep	Time spent sleeping
Sleeplessness	Time spent not being able to sleep
Leisure (Note: we separate watching TV from other types of leisure)	Listening to music
	Playing cards, games, puzzles
	Using computer for leisure
	Arts and crafts
	Reading
	Concerts, movies, lectures
	Singing, playing instrument
	Eating and drinking
	Socializing and communicating
	Attending & hosting events
	Relaxing
	Hobbies
	Attending performances, movies, casinos
Watching TV	Watching TV
Exercise	Sports and Exercise
Grooming	Personal grooming other than sleep
	Health-related self care
	Personal activities
Other time uses	Helping non-family
	Volunteering
	Religious and spiritual time
	Education
	Using professional services
	Using government services
	Travel time other than related to household production
	+all other time uses not included above
Unclassified time	Respondent refusal
	Respondent cannot remember
	Unable to code

4.1. The age profile of time use

As a matter of data description, we begin our discussion with the age-profile of time use for single and married people in the ATUS. These are displayed in Figure 1(a) for single people and Figure 1(b) for married people. Each figure displays the age-profiles of minutes per day allocated to nine activities: home production, market production, sleep, sleeplessness, TV watching, leisure, grooming and personal

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Table II. Summary statistics, 20 years and older, using ATUS data

		Single males	Single females	Married males	Married females
Time uses (Minutes per 24 h)	Home work	115.40	183.83	159.00	270.57
	Market work	247.55	179.91	278.34	178.08
	Sleep	518.27	518.24	494.68	503.86
	Sleeplessness	4.39	6.02	2.87	4.22
	Watching TV	193.35	172.18	170.95	133.78
	Leisure (other than TV)	185.43	185.13	174.52	176.42
	Exercise	25.17	11.30	21.49	12.80
	Grooming	39.41	56.94	36.65	50.26
	Other time[a]	99.91	114.64	90.94	97.61
Demographic variables	Age	41.50	49.92	48.87	46.94
	Good health	0.51	0.44	0.54	0.56
	Bad health	0.18	0.23	0.16	0.14
	White	0.78	0.75	0.87	0.87
	Black	0.16	0.21	0.08	0.07
	Other race[b]	0.05	0.04	0.05	0.06
	Hispanic	0.15	0.12	0.13	0.13
	Less than HS	0.18	0.17	0.15	0.13
	HS graduate	0.30	0.29	0.28	0.29
	Any college	0.45	0.46	0.43	0.48
	Grad degree	0.07	0.07	0.13	0.11
	Any children	0.14	0.27	0.46	0.46
Unpaid home work, disaggregated (Activity groupings according to Bureau of Labor Statistics categories)	Housework	19.63	49.41	14.62	66.18
	Food preparation and cleanup	18.91	34.67	18.88	56.68
	Lawn and garden care	10.95	7.29	21.27	8.99
	Household management	6.36	9.16	7.58	9.56
	Interior maintenance, repair, and decoration	4.68	2.25	7.99	3.93
	Exterior maintenance, repair, and decoration	3.27	1.46	6.98	1.83
	Time spent with animals and pets	4.50	6.00	5.51	6.37
	Vehicle maintenance by respondent	4.45	0.38	4.78	0.55
	Time spent with appliances, tools and toys	1.56	0.53	1.82	0.42
	Travel related to household activities	2.89	2.51	2.34	2.45
	Consumer goods purchases	16.20	26.53	19.17	31.93
	Grocery shopping	4.22	7.26	4.40	8.52
	Purchasing professional and personal care services	0.49	0.56	0.45	0.55
	Purchasing personal care services	0.28	2.18	0.34	1.85
	Purchasing household services	0.70	0.96	1.48	0.73
	Purchasing vehicle maintenance and repair services	0.38	0.47	0.57	0.27
	Travel related to purchasing goods and services	14.35	17.98	16.34	20.99
	Caring for and helping non-household adults	4.74	4.87	4.09	4.22
	Caring for household children	3.18	18.42	23.61	47.79
	Caring for non-household children	2.93	16.31	21.30	42.03

[a]Does not include unclassified time (respondent refused, respondent cannot remember, or unable to code).
[b]Individual belonging to a race other than black or white.

health care, and other time uses. To account for noisiness associated with small cell sizes, the profiles are calculated using 3-year moving averages.

While somewhat of a digression, we would like to highlight the exercise profile which is flat. If one notes that the implied wage-elasticity of exercise is

$$\sigma_{e,w} = \frac{\sigma_{e,a}}{\sigma_{w,a}}$$

where $\sigma_{e,a}$ and $\sigma_{w,a}$ are the age elasticities of exercise and wages, then this suggests that the wage-elasticity of exercise is small. This is notable since, *a priori*, one would expect an increasing profile since

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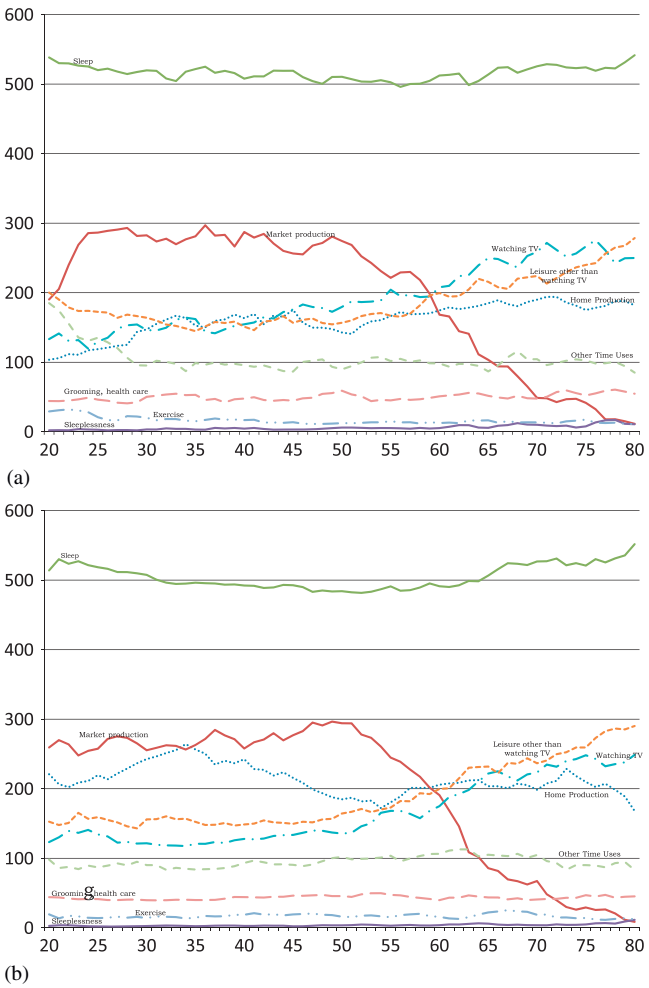

Figure 1. (a) Minutes per day spent with various activities by age, using ATUS data – Singles over 20 years old three-period moving averages of means at each age and (b) Minutes per day spent with various activities by age, using ATUS data – Couples over 20 years old three-period moving averages of means at each age

older people have a lower opportunity cost of time which facilitates greater time allocated to the production of health. In fact, this is a result of the Grossman model under the conditions that the elasticity of demand for health is sufficiently low and the elasticity of substitution between medical care and time in health production is sufficiently high (see footnote 32 of Grossman (1972)). This suggests that medical consumption is the primary input that is used to offset the depreciation of health capital as people age. This may be of interest to structural modelers who are pondering whether or not to include time in the health production function.

4.2. OLS results

We now move on to our regression results in Table III where we report equation-by-equation OLS estimates of the relationship between time use and health status. These results should be interpreted as a succinct summary of the effects of health on time allocation at both the intensive and extensive margins.

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Table III. Estimates of the effect of health status on various time use categories using ATUS data

Dependent variable: Minutes spent with activity per 24 h		Home work	Paid work	Sleep	Sleeplessness	Watching TV	Leisure (exc. TV)	Exercise	Grooming and health	Other time uses
Single males, $N = 5417$	Good health	**7.78**	**3.82**	**−9.08**	**0.18**	**−18.46****	**−4.57**	**9.28****	**4.41***	**7.38**
		(*1.14*)	(*0.44*)	(*−1.58*)	(*0.19*)	(*−2.41*)	(*−0.70*)	(*2.91*)	(*1.79*)	(*1.50*)
	Bad health	**−24.87****	**−70.28*****	**19.08****	**5.98*****	**51.23*****	**24.76****	**−3.92**	**10.02****	**−11.23***
		(*−3.14*)	(*−8.47*)	(*2.57*)	(*3.49*)	(*4.90*)	(*2.78*)	(*−1.17*)	(*2.93*)	(*−1.94*)
Good health–bad health = 0		0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.145	0.002
Single females, $N = 9203$	Good health	**7.78**	**6.27**	**−3.92**	**−0.30**	**−20.07*****	**−2.40**	**3.93****	**3.49****	**4.82**
		(*1.50*)	(*1.11*)	(*−1.01*)	(*−0.46*)	(*−4.16*)	(*−0.52*)	(*3.07*)	(*2.12*)	(*1.22*)
	Bad health	**−23.63*****	**−40.40*****	**28.08*****	**4.03*****	**38.86*****	**1.92**	**−2.49****	**10.36****	**−13.45****
		(*−3.79*)	(*−7.09*)	(*5.10*)	(*4.05*)	(*5.80*)	(*0.33*)	(*−2.04*)	(*3.14*)	(*−3.05*)
Good health–bad health = 0		0.000	0.000	0.000	0.000	0.000	0.451	0.000	0.047	0.000
Married males, $N = 9083$	Good health	**3.73**	**14.03****	**−7.06***	**−0.68**	**−26.78*****	**−3.47**	**6.61****	**1.53**	**9.84****
		(*0.68*)	(*2.11*)	(*−1.92*)	(*−1.22*)	(*−5.69*)	(*−0.79*)	(*2.74*)	(*1.39*)	(*2.59*)
	Bad health	**−13.27***	**−21.54****	**16.91****	**3.38****	**20.80****	**−3.49**	**−7.05****	**5.52****	**−2.55**
		(*−1.72*)	(*−2.32*)	(*2.64*)	(*2.68*)	(*2.49*)	(*−0.50*)	(*−2.70*)	(*2.29*)	(*−0.46*)
Good health–bad health = 0		0.025	0.000	0.000	0.001	0.000	0.997	0.000	0.103	0.024
Married females, $N = 10168$	Good health	**16.27****	**−6.39**	**−0.16**	**−2.23*****	**−21.74*****	**4.29**	**5.48*****	**0.22**	**3.37**
		(*2.80*)	(*−1.23*)	(*−0.05*)	(*−3.55*)	(*−5.79*)	(*1.04*)	(*3.77*)	(*0.14*)	(*0.94*)
	Bad health	**−11.10**	**−22.05****	**12.30****	**1.53**	**24.36*****	**7.26**	**−3.47****	**3.62**	**−17.82*****
		(*−1.41*)	(*−3.26*)	(*2.12*)	(*1.51*)	(*3.85*)	(*1.10*)	(*−2.07*)	(*1.14*)	(*−3.90*)
Good health–bad health = 0		0.000	0.017	0.028	0.000	0.000	0.643	0.000	0.271	0.000

Notes: OLS regressions. Good health refers to self-reported excellent or very good health. Bad health refers to self-reported fair or poor health. We omit the middle health category (self-reported health = good). *T*-statistics are shown in parentheses. Significance levels shown are 1% (***), 5% (**) and 10% (*). The time use categories shown add up to 24 h less uncategorized/unreported time (respondent refused, cannot remember, or unable to code). A full set of age dummies is also included in the regressions, in addition to controlling for race, education, the presence of children, day, year, and spousal characteristics if applicable. The full regressions are available on request. We report the *p*-value on the test that the difference between good and bad health is zero.

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In addition to reporting the coefficients on good and bad health, we also report *p*-value from a test that the difference between good and bad health is zero.

For both married and single people, we observe that healthier people allocate more time to both home and market production, although the partial correlations are larger for the latter than for the former. Within the context of our model, the former result implies that health has larger effects on non-market than on market efficiency (i.e. $w'(H) < A'(H)f'(m)$)). However, we also observe large positive effects on market production. While this is not a surprising result, it is interesting that healthier people allocate more time to all productive activities at the expense of a lower consumption of leisure. To generate both of these results, our model implies that the market effects of health must be sufficiently large, although the non-market effects must be larger.

Next, note that the estimates for each health category sum to approximately zero. In fact, if we were to have reported the coefficients from the unclassified time equation they would sum to exactly zero. This is the consequence of an aggregation condition that is obtained by differentiating the time constraint with respect to health status.

In Figure 2, we plot the difference between the coefficients on good and bad health for nine time uses by marital status and gender. First, the figure shows that the responsiveness of time use to health is lower for married people than it is for single people for home work, paid work, sleep, sleeplessness, watching TV, and leisure. Note that because of the aggregation condition that the coefficients across time uses must sum to zero, a higher positive elasticity for some uses should be accompanied by higher negative elasticities for other uses which is precisely what the figure shows. Finally, the figure bears a nice relationship with the results of Biddle and Hamermesh (1990) and Mullahy and Robert (2010) in that it shows that better health is associated with more time exercising and less time sleeping.

We speculate that the effects of health are lower for couples because there are fewer substitutes for their time than for singles. For example, a single person who falls ill may be able to hire someone to clean their house once a week, but a married person with children may have a harder time hiring someone to dress their children, make them breakfast, and shuttle them to school in the morning. There also is a weaker pattern in which the effects of health are the lowest for married women. However, the effects of health on home production are higher for married women than for married men, but the reverse is true for paid work. This is notable as one might expect the responsiveness of home production to health to be lower for married women due to social conventions that say that the home is the woman's domain and, so one might expect women to supply their labor at home regardless of whether or not they are sick.[6]

4.3. Extensive vs intensive margins

We now investigate the effects of health on time use at the extensive and intensive margins. To assess the effects at the extensive margins, we estimate separate Probits for each time use and report the marginal effects of these estimations. These can be viewed as the empirical analogues of the decision rules displayed in Equations (2) and (5). As has been done by others in the time-use literature (e.g. Hamermesh (2010)), we assess the effects at the intensive margins by estimating separate Tobits and report the coefficient estimates.[7] These estimations are the empirical analogues of Equations (3) and (6).

[6]Some words should be mentioned concerning robustness and sensitivity. All of our results include a comprehensive set of controls for individual and household demographic characteristics. In addition, age is controlled in a fully non-parametric fashion using age dummies. Using paid and home work and looking at singles, including the controls in a step-wise fashion resulted only in small changes in bad health, which was the only significant health variable, although the changes were somewhat larger for women.

[7]The coefficients from a Tobit model are the marginal effects of the independent variable on the expectation of the dependent variable conditional on the independent variable and the dependent variable being positive.

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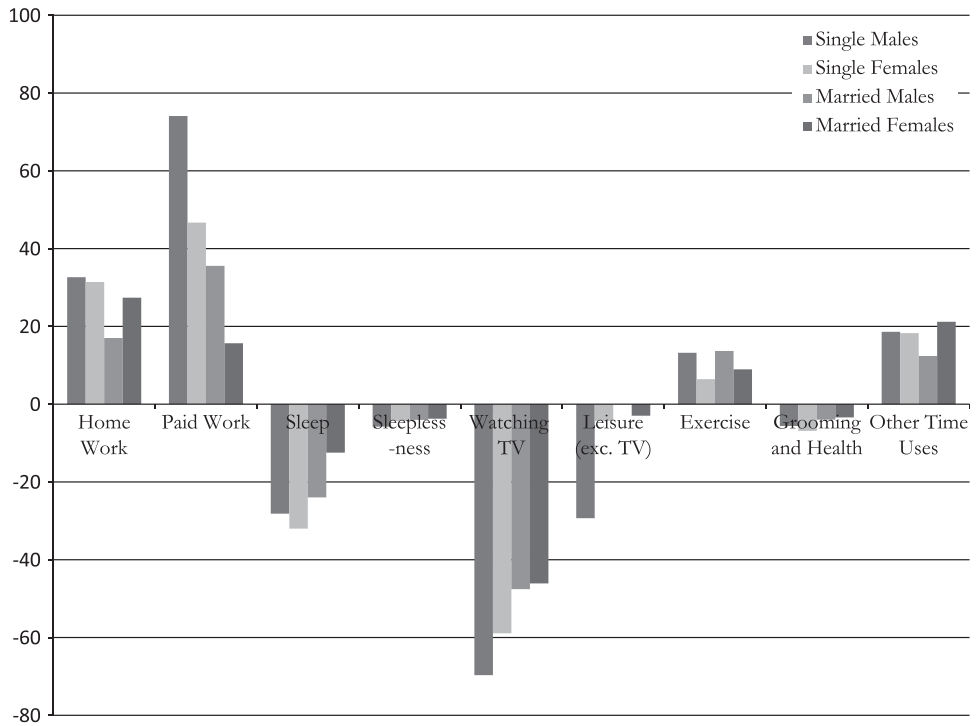

Figure 2. Regression coefficient for good health minus regression coefficient for bad health. OLS. This figure was produced using Table IV

This procedure can be viewed as a simple version of the two-part model which is commonly employed in health economics as discussed in Manning *et al.* (1987) and Mullahy (1998).[8]

The results are in Table IV. For the sake of saving space, we only report results for home and paid work. We see a nice dichotomy across married and single people. At the intensive margin, the effects of health on home production are larger for singles, but at the extensive margin, they are larger for married people. This second result suggests that the labor supply of mothers and fathers is lumpy at home. We speculate that married couples supply their labor at home somewhat inelastically unless they are sufficiently disabled in which case they do not work at all. On the other hand, the tables show that the effects of health on market work are larger for singles than for couples at both margins.

4.4. Effects on home production by its constituents

We conclude with Tables V and VI where we report estimates of Tobits using the constituents of the home work variable as dependent variables for singles and couples. In each panel of the tables, we report the results for men and women and we arrange the categories by the difference between the good and bad health coefficients. The top categories are the time uses that are the most responsive to health, whereas the bottom categories are the time uses that are the least responsive.

[8]The Tobit model that we estimate, which is the Type I Tobit as described by Amemiya (1985), delivers a binary choice probability, so one might wonder why we estimated a separate Probit rather than use the marginal effects (at the extensive margin) that are delivered by the Tobit estimation procedure. The reason is that, in this stripped down Tobit, the Probit coefficients are restricted to be the coefficients from the linear index of the expectation of the continuous variable (conditional on positive values) divided by the variance of the residuals. Our procedure does not impose this restriction and so is more flexible.

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Table IV. Estimates of the effect of health status on various time use categories using ATUS data – Singles intensive and extensive margins reported

		Single males $N = 5417$		Married males $N = 9083$	
Dependent variable: Minutes spent with activity per 24 h		Home work	Paid work	Home work	Paid work
Goodhealth	Tobit	**7.22**	**6.65**	**4.15**	**33.96****
		−0.93	*−0.31*	*−0.68*	*−2.35*
	Probit	**−0.02**	**0.03**	**0.02**	**0.08****
		(−0.27)	*−0.56*	*−0.46*	*−2.23*
Badhealth	Tobit	**−29.05****	**−281.52*****	**−18.32****	**−75.20****
		(−3.18)	*(−9.36)*	*(−2.04)*	*(−3.13)*
	Probit	**−0.1**	**−0.60*****	**−0.14****	**−0.20*****
		(−1.42)	*(−8.94)*	*(−2.17)*	*(−3.42)*
Good health–bad health = 0	Tobit	0.000	0.000	0.011	0.000
	Probit	0.215	0.000	0.010	0.000
		Single females $N = 9203$		Married females $N = 10168$	
		Home work	Paid work	Home work	Paid work
Goodhealth	Tobit	**8.78**	**21.43**	**17.10****	**−16.62*****
		−1.6	*−1.17*	*−2.86*	*(−3.68)*
	Probit	**0.08**	**0.05**	**0.12**	**−0.03**
		−1.54	*−1.28*	*−1.59*	*(−0.69)*
Badhealth	Tobit	**−26.41*****	**−205.63*****	**−13.56**	**−93.05*****
		(−3.93)	*(−8.06)*	*(−1.63)*	*(−23.57)*
	Probit	**−0.16****	**−0.42*****	**−0.18****	**−0.21*****
		(−2.60)	*(−7.93)*	*(−2.14)*	*(−3.68)*
Good health–bad health = 0	Tobit	0.000	0.000	0.000	0.000
	Probit	0.000	0.000	0.001	0.001

Notes: Tobit and Probit regressions. For probit, marginal effects are reported. Good health refers to self-reported excellent or very good health. Bad health refers to self-reported fair or poor health. We omit the middle health category (self-reported health = good). *T*-statistics are shown in parentheses. Significance levels shown are 1% (***), 5% (**) and 10% (*). The time use categories shown add up to 24 h less uncategorized/unreported time (respondent refused, cannot remember, or unable to code). The regressions control for age, race, education, the presence of children, day, and year, and spousal characteristics where applicable. The full regressions are available on request. We report the *p*-value on the test that the difference between good and bad health is zero.

The table reveals some interesting patterns. Looking at single men and women, the five activities with the largest responses almost coincide perfectly with the exception that purchasing vehicle maintenance is in the top five for women, while purchasing professional services is in the top five for men. So, it appears as if single men and women who are ill tend to neglect their homes inside and out.

Looking at married people, we see similar results. While we do not see that the same exact activities are listed in the top five for married men and women as we did for singles, we do see that the same types of activities are listed. Married men have high responses for doing home work and vehicle maintenance. Married women also have high responses for various types of home maintenance and improvement activities. Once again, we see that one of the costs of poor health appears to be neglecting your home. However, one difference between men and women is that married men have high responses for caring for non-household adults, whereas the opposite is true for women. This suggests that the burden of caring for aging grandparents may fall upon the wife.

5. CONCLUSIONS

So, how does time allocation vary with health status? Better health is associated with more time allocated toward production on the market and at home, but less consumption of leisure. These

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Table V. Breakdown of unpaid time uses in the ATUS – Singles

	Single males, $N = 5417$	Goodhealth		Badhealth		Good health–bad health significance	
Top five activities	Exterior maintenance, repair, and decoration	**−2.82**	(*−0.084*)	**−123.591****	(*−2.724*)	**120.77**	0.00
	Interior maintenance, repair, and decoration	**30.31**	(*0.795*)	**−36.74**	(*−0.710*)	**67.05**	0.20
	Lawn and garden care	**23.70**	(*1.281*)	**−39.563***	(*−1.704*)	**63.26**	0.00
	Purchasing personal care services	**1.74**	(*0.099*)	**−58.792****	(*−1.993*)	**60.53**	0.04
	Purchasing vehicle maintenance and repair services	**−6.56**	(*−0.279*)	**−52.67**	(*−1.607*)	**46.11**	0.14
	Vehicle maintenance by respondent	**4.92**	(*0.205*)	**−29.59**	(*−1.006*)	**34.50**	0.22
	Caring for and helping non-household adults	**1.35**	(*0.129*)	**−23.333***	(*−1.662*)	**24.68**	0.07
	Time spent with appliances, tools, and toys	**−68.950****	(*−2.366*)	**−90.260****	(*−2.254*)	**21.31**	0.58
	Consumer goods purchases	**5.56**	(*1.412*)	**−11.301****	(*−2.356*)	**16.86**	0.00
	Household management	**−9.08**	(*−1.262*)	**−25.437****	(*−2.856*)	**16.36**	0.07
	Caring for non-household children[a]	**23.965***	(*1.834*)	**10.05**	(*0.588*)	**13.92**	0.39
	Caring for household children[a]	**18.66**	(*1.367*)	**6.48**	(*0.362*)	**12.17**	0.47
	Travel related to purchasing goods and services	**3.81**	(*1.360*)	**−6.374***	(*−1.781*)	**10.19**	0.00
	Time spent with animals and pets	**−1.57**	(*−0.261*)	**−7.96**	(*−1.068*)	**6.39**	0.36
	Purchasing household services	**−6.07**	(*−0.348*)	**−11.40**	(*−0.542*)	**5.33**	0.78
	Travel related to household activities	**−1.61**	(*−0.384*)	**−4.86**	(*−0.925*)	**3.25**	0.51
	Grocery shopping	**1.92**	(*0.434*)	**−0.67**	(*−0.123*)	**2.58**	0.62
	Housework	**−8.61**	(*−1.047*)	**−8.49**	(*−0.835*)	**−0.12**	0.99
	Food preparation and cleanup	**0.88**	(*0.255*)	**3.00**	(*0.735*)	**−2.12**	0.57

	Single females, $N = 9203$	Goodhealth		Badhealth		Good health–bad health significance	
Top five activities	Lawn and garden care	**10.05**	(*0.901*)	**−61.806*****	(*−4.609*)	**71.85**	0.00
	Purchasing personal care services	**27.968***	(*1.754*)	**−31.64**	(*−1.498*)	**59.60**	0.00
	Exterior maintenance, repair, and decoration	**−7.51**	(*−0.324*)	**−59.708***	(*−1.902*)	**52.20**	0.09
	Vehicle maintenance by respondent	**5.27**	(*0.265*)	**−42.80**	(*−1.390*)	**48.07**	0.08
	Interior maintenance, repair, and decoration	**27.36**	(*1.089*)	**−3.18**	(*−0.114*)	**30.54**	0.28
	Consumer goods purchases	**5.56**	(*1.535*)	**−24.320*****	(*−5.373*)	**29.88**	0.00
	Caring for and helping non-household adults	**5.70**	(*0.728*)	**−21.819****	(*−2.238*)	**27.52**	0.01
	Purchasing vehicle maintenance and repair services	**10.40**	(*0.706*)	**−14.75**	(*−0.733*)	**25.16**	0.21
	Housework	**7.22**	(*1.383*)	**−14.398****	(*−2.286*)	**21.62**	0.00
	Purchasing household services	**11.16**	(*1.097*)	**−10.05**	(*−0.695*)	**21.21**	0.12
	Household management	**8.157***	(*1.747*)	**−8.13**	(*−1.398*)	**16.28**	0.01
	Grocery shopping	**7.439****	(*2.165*)	**−8.302****	(*−1.982*)	**15.74**	0.00
	Travel related to purchasing goods and services	**4.157****	(*2.135*)	**−11.324*****	(*−4.495*)	**15.48**	0.00
	Travel related to household activities	**0.94**	(*0.305*)	**−7.545****	(*−1.964*)	**8.49**	0.03
	Time spent with animals and pets	**0.83**	(*0.258*)	**−0.64**	(*−0.158*)	**1.48**	0.72
	Time spent with appliances, tools, and toys	**−18.77**	(*−1.195*)	**−17.14**	(*−0.767*)	**−1.63**	0.94
	Food preparation and cleanup	**−1.32**	(*−0.537*)	**0.49**	(*0.167*)	**−1.81**	0.53
	Caring for non-household children[a]	**−4.80**	(*−0.930*)	**−2.59**	(*−0.396*)	**−2.21**	0.73
	Caring for household children[a]	**−3.59**	(*−0.651*)	**−1.37**	(*−0.197*)	**−2.22**	0.75

Notes: Tobit regressions. Refer to Table IV notes.
[a]These regressions do not contain controls for children.

correlations are larger for time allocated to the market than to the home. If we interpret this finding within the context of a model of time allocation borrowed from Gronau (1980), this suggests that health exerts large effects on market efficiency, but larger effects on non-market efficiency. We find that the time use of married people is less elastic than for single people at the intensive margin, but more elastic at the extensive margin. Finally, we show that the partial correlations between health and home production are larger for singles than for couples.

Our result that healthier people work more at home has a nice concordance with a recent paper by Hamermesh and Lee (2007). They argue that anything that raises efficiency should relax time

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Table VI. Breakdown of unpaid time uses in the ATUS – 'Couples'

	Married Males, $N = 9083$	Goodhealth		Badhealth		Good health–bad health significance	
Top five activities	Purchasing personal care services	**−8.27**	(*−0.536*)	**−56.346****	(*−2.374*)	**48.08**	0.03
	Exterior maintenance, repair, and decoration	**31.00**	(*1.411*)	**−11.52**	(*−0.370*)	**42.53**	0.17
	Vehicle maintenance by respondent	**16.66**	(*1.203*)	**−9.21**	(*−0.461*)	**25.87**	0.18
	Caring for and helping non-household adults	**−3.75**	(*−0.345*)	**−25.51**	(*−1.314*)	**21.76**	0.26
	Time spent with appliances, tools, and toys	**6.14**	(*0.356*)	**−12.90**	(*−0.439*)	**19.04**	0.52
	Interior maintenance, repair, and decoration	**12.66**	(*0.546*)	**−4.38**	(*−0.116*)	**17.04**	0.63
	Household management	**6.31**	(*1.456*)	**−10.50**	(*−1.577*)	**16.81**	0.01
	Lawn and garden care	**−2.52**	(*−0.209*)	**−17.39**	(*−1.009*)	**14.86**	0.37
	Consumer goods purchases	**−1.72**	(*−0.526*)	**−11.040****	(*−2.194*)	**9.32**	0.06
	Travel related to purchasing goods and services	**0.54**	(*0.267*)	**−7.137****	(*−2.358*)	**7.68**	0.01
	Housework	**−9.80**	(*−1.592*)	**−15.29**	(*−1.608*)	**5.50**	0.55
	Caring for household children[a]	**5.91**	(*1.378*)	**1.58**	(*0.222*)	**4.32**	0.53
	Caring for non-household children[a]	**5.69**	(*1.361*)	**1.44**	(*0.206*)	**4.26**	0.52
	Time spent with animals and pets	**−0.58**	(*−0.125*)	**−3.09**	(*−0.465*)	**2.51**	0.69
	Food preparation and cleanup	**−0.08**	(*−0.028*)	**−0.41**	(*−0.090*)	**0.33**	0.94
	Travel related to household activities	**−0.40**	(*−0.086*)	**−0.67**	(*−0.105*)	**0.26**	0.97
	Grocery shopping	**−2.79**	(*−0.674*)	**−2.68**	(*−0.435*)	**−0.11**	0.99
	Purchasing household services	**−9.96**	(*−0.754*)	**−8.16**	(*−0.420*)	**−1.80**	0.92
	Purchasing vehicle maintenance and repair services	**−36.146****	(*−1.968*)	**−20.49**	(*−0.837*)	**−15.65**	0.53
	Married Females, $N = 10\,168$	Goodhealth		Badhealth		Good health–bad health significance	
Top five activities	Lawn and garden care	**30.680****	(*2.636*)	**−52.496****	(*−3.015*)	**83.18**	0.00
	Exterior maintenance, repair, and decoration	**30.61**	(*1.312*)	**−18.10**	(*−0.526*)	**48.71**	0.14
	Interior maintenance, repair, and decoration	**−9.39**	(*−0.414*)	**−49.78**	(*−1.345*)	**40.39**	0.27
	Purchasing vehicle maintenance and repair services	**−11.02**	(*−1.003*)	**−43.729****	(*−2.281*)	**32.71**	0.06
	Purchasing personal care services	**20.84**	(*1.326*)	**−8.91**	(*−0.381*)	**29.75**	0.17
	Purchasing household services	**−1.68**	(*−0.213*)	**−26.17**	(*−1.625*)	**24.49**	0.12
	Vehicle maintenance by respondent	**−26.572***	(*−1.788*)	**−44.318****	(*−2.285*)	**17.75**	0.32
	Consumer goods purchases	**4.89**	(*1.495*)	**−12.118****	(*−2.328*)	**17.01**	0.00
	Travel related to household activities	**2.94**	(*0.848*)	**−11.065****	(*−2.136*)	**14.00**	0.01
	Grocery shopping	**5.25**	(*1.610*)	**−7.66**	(*−1.471*)	**12.91**	0.01
	Caring for non-household children[a]	**5.63**	(*1.520*)	**−6.89**	(*−1.146*)	**12.52**	0.03
	Travel related to purchasing goods and services	**2.28**	(*0.836*)	**−8.697****	(*−2.562*)	**10.97**	0.00
	Household management	**1.24**	(*0.365*)	**−9.25**	(*−1.612*)	**10.49**	0.06
	Caring for household children[a]	**5.58**	(*1.419*)	**−3.96**	(*−0.625*)	**9.54**	0.12
	Time spent with animals and pets	**3.61**	(*0.981*)	**−3.17**	(*−0.537*)	**6.79**	0.24
	Housework	**5.40**	(*1.173*)	**4.09**	(*0.592*)	**1.30**	0.85
	Food preparation and cleanup	**4.064***	(*1.720*)	**5.24**	(*1.394*)	**−1.18**	0.74
	Caring for and helping non-household adults	**−2.54**	(*−0.325*)	**2.15**	(*0.188*)	**−4.69**	0.68
	Time spent with appliances, tools, and toys	**−8.91**	(*−0.486*)	**7.94**	(*0.258*)	**−16.84**	0.57

Notes: Tobit regressions. Refer to Table IV notes.
[a]These regressions do not contain controls for children.

constraints and, hence the shadow price of time. Consistent with their theoretical predictions, they provide evidence using data from Australia, Germany, and the United States that healthier people report a lower prevalence of time stress holding other factors constant. Our result supports theirs since it implies that healthier people are more efficient at home production.

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REFERENCES

Amemiya T. 1985. *Advanced Econometrics*. Harvard University Press: Cambridge.

Baker M, Stabile M, Deri C. 2004. What do self-reported, objective measures of health measure. *Journal of Human Resources* **39**(4): 1067–1093.

Becker G. 1964. *Human Capital*. Columbia University Press: New York.

Ben-Porath Y. 1967. The production of human capital and the life cycle of earnings. *Journal of Political Economy* **75**(4): 352–365.

Biddle J, Hamermesh D. 1990. Sleep and the allocation of time. *Journal of Political Economy* **98**(5): 922–043.

Bird C, Freemont A. 1991. Gender, time use and health. *Journal of Health and Social Behavior* **32**(2): 114–129.

Bound J. 1991. Self-reported versus objective measures of health in retirement models. *Journal of Human Resources* **26**(1): 106–138.

Coile C. 2004. Health shocks and couples labor supply decisions. *NBER Working Paper*.

Deaton A. 2010. Instruments, randomization, and learning about development. *Journal of Economic Literature* **48**(2): 425–455.

French E. 2005. The effect of health, wealth, and wages on labour supply and retirement behaviour. *Review of Economic Studies* **72**(2): 395–427.

Gronau R. 1980. Home production – a forgotten industry. *Review of Economics and Statistics* **62**(3): 408–416.

Grossman M. 1972. On the concept of health capital and the demand for health. *Journal of Political Economy* **80**(2): 223–255.

Hallberg D, Klevmarken A. 2003. Time for children: a study of parents time allocation. *Journal of Population Economics* **16**(2): 205–226.

Halliday T. 2010. Income risk and health. *Unpublished Mimeo*.

Hamermesh D. 2010. Incentives, time use, and bmi: The roles of eating, grazing, and goods. *Economics and Human Biology* **8**(1): 2–15.

Hamermesh D, Lee J. 2007. Stressed out on four continents: time crunch or yuppie kvetch. *Review of Economics and Statistics* **89**(2): 374–383.

MacDonald M, Phipps S, Lethbridge L. 2005. Taking its toll: the influence of paid and unpaid work on women's well-being. *Feminist Economics* **11**(1): 63–94.

Manning W, Duan N, Rogers W. 1987. Monte carlo evidence on the choice between sample selection and two-part models. *Journal of Econometrics* **35**(1): 59–82.

Mullahy J. 1998. Much ado about two: reconsidering retransformation and the two-part model in health econometrics. *Journal of Health Economics* **17**(3): 247–281.

Mullahy J, Robert SA. 2010. No time to lose: time constraints and physical activity. *Review of Economics of the Household* **8**(4): 409–432.

Palumbo M. 2003. Uncertain medical expenses and precautionary saving near the end of the life cycle. *Review of Economic Studies* **66**(2): 395–421.

Prowse V. 2009. Modeling the allocation of time under rationing: a structural model of time allocation behavior. *Canadian Journal of Economics* **42**(1): 90–112.

Rosen H, Wu S. 2004. Portfolio choice and health status. *Journal of Financial Economics* **72**(3): 457–484.

Rust J, Phelan C. 1997. How social security and medicare affect retirement behavior in a world of incomplete markets. *Econometrica* **65**(4): 781–831.

Smith J. 1999. Healthy bodies and thick wallets: the dual relation between health and economic status. *Journal of Economic Perspectives* **13**(2): 145–166.

Smith J. 2003. Health and ses across the life course. *Unpublished Mimeo*.

Wu S. 2003. The effect of health events on the economic status of married couples. *Journal of Human Resources* **38**(1): 219–230.

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