Health, Human Capital, and Life Cycle Labor Supply

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The fundamental importance of human and health capital on labor market outcomes is well known (Grossman 1972; Weiss 1972). Higher levels of human capital, both through formal schooling and on-the-job experience, lead to higher wages and income, while good health increases the number of healthy days to consume goods and leisure. Perhaps surprising, most human capital papers have ignored the role of health, and most health papers have ignored its effect on endogenous human capital (Heckman 1976; Shaw 1989; nd Yazbeck 1998; Imai and Keane 2004; French 2005; Blundell, et al. 2013). However, if health affects how much an individual works, and how much an individual works determines the skills acquired on the job, then variations in health will influence human capital and, subsequently, future labor supply choices and income. This suggests an interaction between health and human capital that has not been addressed, and yet ignoring it could lead to a biased assessment of how health and wages, and attendant public policies such as taxes and transfers, affect labor supply over the life cycle.

We estimate a structural model of life cycle labor supply of men that combines health production with learning-by-doing using newly available data on consumption and health in the Panel Study of Income Dynamics (PSID). Prior to 1999 the only consistent consumption measure was food spending. Since then the PSID has collected rich data on consumption expenditures, enabling us to isolate medical out-of-pocket spending from nonmedical spending.

Likewise, research on health in the PSID had been limited to the standard self-rated index of global health, with a paucity of possible instruments. The PSID now collects other health conditions, including height and weight used to construct body mass index (BMI). The rise of obesity in the U.S. has been linked to a number of poor health conditions such as type II diabetes, high blood pressure, heart disease, and certain forms of cancer. Many of the obesity-related conditions are not permanently disabling in the sense of requiring labor-force exit, but do make the individual more susceptible to illness that may require periods out of work and thus interrupting the human capital process.

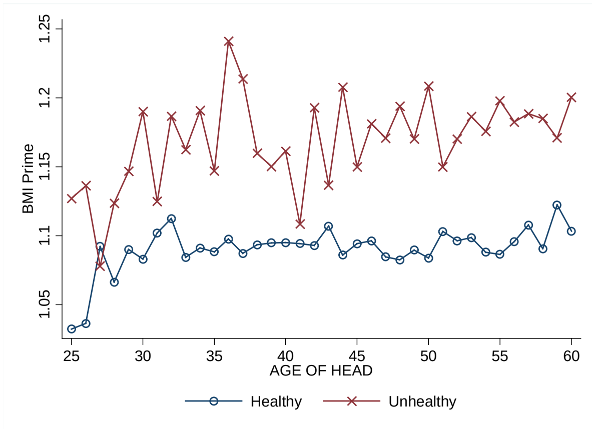

FIGURE 1. BMI PRIME OVER LIFE CYCLE

In Figure 1 we depict average levels of BMI Prime (BMI relative to 25, the cutoff for overweight) at each age among men in our sample. It is clear that the average man in the PSID is overweight since BMI Prime exceeds 1, but unhealthy men (those with self-rated health of good, fair, or poor) are much heavier on average than healthy men (those with self-rated health of very good or excellent), suggesting that BMI might be a good instrument for overall health.

I. Modeling Labor Supply

The individual chooses hours of work (N_t), nonmedical consumption (C_t), and medical spending (M_t) to maximize the present discounted value of uncertain and time-separable utility defined over leisure (L_t), nonmedical consumption, and the stock of health (H_t), $U(L_t, C_t, H_t)$:

$$(1) \qquad V(A_t, K_t, H_t) = U(L_t, C_t, H_t) + \beta E_t[V(A_{t+1}, K_{t+1}, H_{t+1})]$$

where $V(A_t, K_t, H_t)$ is the value function determined by the stocks of assets (A_t), human capital (K_t), and health capital (H_t); $\beta = 1/(1+\rho)$ is the discount factor based on rate of time preference (ρ); and E_t is the time t expectations operator reflecting that there is uncertainty over future earnings and health.

Income comes from interest on prior period assets ($r_t A_t$) and labor earnings ($w_t N_t$), where r_t is a time t interest rate on composite assets and w_t is the before-tax hourly wage rate. Income can be spent on nonmedical consumption with a normalized price of 1, on medical services at the price p_t^m, or can be saved and carried to the next period. The resulting asset accumulation constraint is:

$$(2) \quad A_{t+1} = (1 + r_t)(A_t + w_t N_t - C_t - p_t^m M_t).$$

Following Shaw (1989), we specify the observed wage (w_t) as the product of the human capital stock and the unobserved rental rate on human capital (R_t), $w_t = R_t K_t$. In each period an individual inherits a stock of human capital that depreciates at rate δ_K. New investment occurs on the job through learning-by-doing that depends on hours worked and human and health capital, $x(N_t, K_t, H_t)$:

(3) $\quad K_{t+1} = (1-\delta_K)K_t + x(N_t, K_t, H_t)$.

That is, hours of work determine not only current period utility, but also future utility via wages because of learning on the job.

Likewise, in each period an individual inherits a stock of health that depreciates at rate δ_H. Health can be replenished by devoting leisure time to exercise, and purchasing medical services, $y(M_t, L_t)$, evolving as

(4) $\quad H_{t+1} = (1-\delta_H)H_t + y(M_t, L_t)$.

Medical spending is isolated from nonmedical spending as the former is a direct input into the production of good health—higher out-of-pocket medical spending is treated as an investment in good health. Leisure time is also an input into the production of good health in that leisure (or at least some portion) is spent in exercise and other health-promoting activities, creating an implicit tradeoff between human capital production and health capital production. The potential amount of leisure time spent in health production, and likewise the hours of work spent in human capital production, are governed by "healthy time" (ht_t), $L_t + N_t = ht_t$. Total time in a period (T) is the sum of healthy time and sick time (s_t), $ht_t + s_t = T$.

The human and health capital production functions generate nonseparabilities in the intertemporal budget constraint because stocks depreciate over time. The forcing variable is the assumption of exogenous health shocks that have a direct effect on sick time. The basic idea is that a poor health shock reduces future wages via two channels—a direct effect on future productivity and an indirect effect of lowering labor supply in the current period, which in turn reduces the amount of human capital gained on the job.

We combine the envelope conditions for the state variables with the first-order conditions to solve the optimization problem. This yields a standard intertemporal Euler equation for nonmedical consumption, along with time-nonseparable Euler equations for hours of work and medical spending. The resulting system is highly nonlinear, and thus we follow Shaw (1989) to implement a two-stage GMM procedure. In stage one we estimate health and human capital production functions, and in stage two we treat the latter as known parameters to estimate utility preferences. We specify human capital (i.e. wages) as a quadratic function of past wages, hours, health, and interactions among the three factors. Likewise, we specify current health as a function of lagged health, leisure, medical spending, and interactions of the three factors. The utility function is direct translog, which admits nonseparability among current consumption, leisure, and health.

II. Data

Men are drawn from the Survey Research Center subsample of the PSID from 1999-2009 who meet the following criteria: (1) head of household; (2) work at least 3 years; (3) between the ages of 25 and 60; (4) real net hourly wages between \$2 and \$300; (5) real annual food spending greater than \$500 and less than \$80,000; (6) real total spending between the 0.5 and the 99.5 percentiles; and (7) real consumption growth between -80 and 300 percent. The sample contains 1,654 men and 9,052 person-years.

The key labor supply variable for our analysis is annual hours of work on all jobs. Healthy time is 8,760 less sick hours, defined as the amount of work missed due to own illness or others' illness. Self-rated health, which ranges from 1 (poor) to 5 (excellent), serves as the health stock measure.

Nonmedical spending is constructed by summing food at home and away (including food stamps and home delivered meals), gasoline and other transportation, utilities, education and child care, homeowner insurance, and rent paid, which includes payments by renters as well as imputed rent for homeowners calculated as 6 percent of the house value. Medical out-of-pocket spending includes surgical and dental, hospitalizations, health insurance premiums, and prescription drugs. Medical and nonmedical spending are adjusted by the square root of family size. Financial data are deflated by the personal consumption expenditure deflator for 2006.

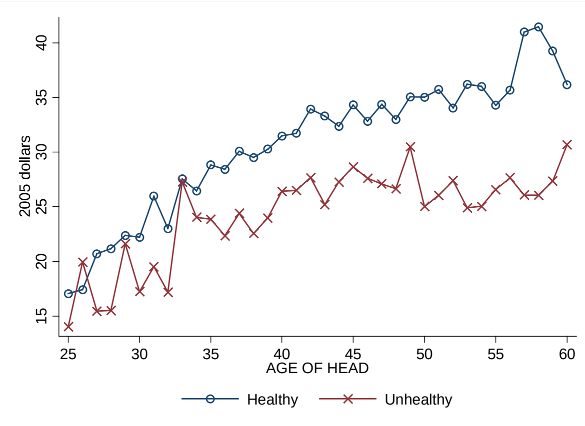

FIGURE 2. REAL HOURLY WAGES OVER LIFE CYCLE

Figure 2 depicts the age-specific average real wage by health status. Overall, healthy men earn \$6.22 more per hour than unhealthy men, but by age 35 the hourly wage begins to diverge quite dramatically. Likewise, healthy men work about 94 hours more per year, or more than two weeks at full time, in part because they report 24 hours more annual sick time. However, Figure 3 shows that the hours of work difference is more dispersed across the life cycle than wages. On the other hand, Figure 4 shows that the lifetime of lower wages and hours of work translates into substantially lower net worth, averaging nearly $150,000 less for unhealthy men. Again, this divergence emerges around age 35, suggesting that health shocks early in the human capital accumulation process transmit into a future of lower wages and wealth.

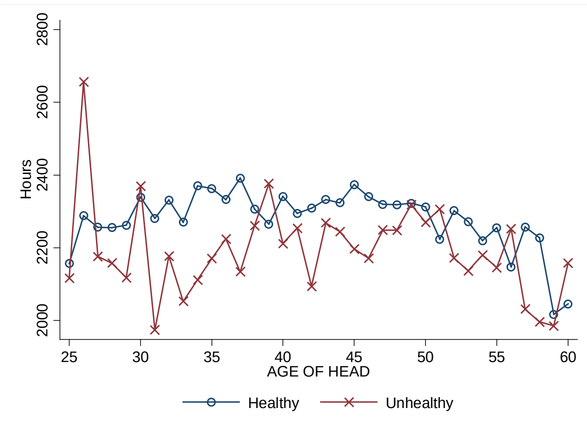

FIGURE 3. ANNUAL HOURS OF WORK OVER LIFE CYCLE

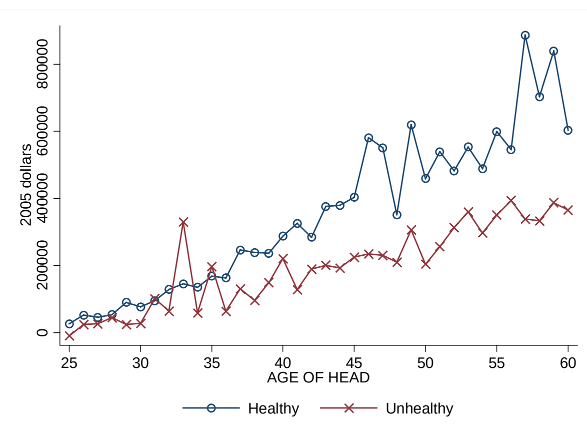

FIGURE 4. REAL NET WORTH OVER LIFE CYCLE

III. Results

Table 1 records results for the human and health capital production models, along with the within-period translog utility parameters. The instruments consist of the time t values of the regressors, along with demographics and state economic conditions and policies.

The large effect of the current wage and its square indicates strong persistence in wages, with future wages increasing at a decreasing rate in the current wage, i.e. diminishing marginal productivity. The interaction between wages and hours worked suggests that hours worked and human capital are complements, consistent with learning-by-doing technology. At the same time, the interaction between wages and health suggests that human capital and health capital are complements.

To explore further the effect of current human and health capital on future human capital, in Table 2 we present partial effects of hours and health on wages. The marginal product of hours on wages evaluated at the mean values of the variables is equal to 0.10. This means an increase in annual hours by 500 (just under a standard deviation) increases the wage next period by 2.6 percent, or an elasticity of 0.12. We note that this is much smaller than the 8 percent effect reported in Keane (2011) using Shaw's (1989) estimates. We believe this comes from our inclusion of health in the human capital process, which dampens learning-by-doing.

In the bottom panel of Table 2 we show the marginal product of health on human capital.

TABLE 1—GMM ESTIMATES OF HEALTH AND HUMAN CAPITAL PRODUCTION AND UTILITY

Human Capital Production			Health Capital Production			Utility Function		
Parameter	Estimate	Std. Err.	Parameter	Estimate	Std. Err.	Parameter	Estimate	Std. Err.
w_t	0.714***	(0.142)	H_t	0.690***	(0.137)	$\ln L_t$	1.00	
w_t^2	-0.047***	(0.006)	H_t^2	0.001	(0.010)	$\ln C_t$	0.062***	(0.019)
w_tN_t	0.078**	(0.032)	H_tL_t	-0.008	(0.016)	$\ln L_t \ln C_t$	-0.036***	(0.005)
N_t	0.186	(0.172)	L_t	0.130	(0.136)	$(\ln L_t)^2$	-0.270***	(0.005)
N_t^2	-0.046**	(0.023)	L_t^2	-0.009	(0.010)	$(\ln C_t)^2$	-0.001	(0.001)
H_t	-0.100	(0.083)	M_t	0.014	(0.045)	$\ln H_t$	0.071	(1.700)
H_t^2	0.007	(0.011)	M_t^2	-0.001	(0.001)	$\ln H_t \ln L_t$	0.053***	(0.007)
H_tN_t	-0.007	(0.028)	H_tM_t	0.004	(0.005)	$\ln H_t \ln C_t$	0.013	(0.009)
w_tH_t	0.067**	(0.029)	L_tM_t	-0.001	(0.006)	$(\ln H_t)^2$	-0.046	(0.675)
Sargan	49.95		Sargan	158.4		Sargan	66.90	
test [df]	[8]		test [df]	[8]		test [df]	[88]	
p-value	0.00		p-value	0.00		p-value	0.95	

Notes: All models control for time effects. Standard errors are robust to conditional heteroskedasticity. *** Significant at the 1 percent level. ** Significant at the 5 percent level.

TABLE 2—THE EFFECT OF WORK AND HEALTH ON HUMAN CAPITAL

Human Capital Partial Effect	Full Sample	Healthy	Unhealthy
Marginal Product of N_t on W_{t+1}	0.10	0.10	0.10
Percent Change in N_t (500 hours)	22.1%	21.8%	22.8%
Percent Change in W_{t+1}	2.6%	2.5%	2.9%
Marginal Product of H_t on W_{t+1}	0.07	0.09	0.04
Percent Change in H_t (1 unit)	25.7%	22.7%	36.1%
Percent Change in W_{t+1}	1.3%	1.5%	0.7%

Notes: Calculations based on production parameters in Table 1 and mean values of variables.

Here we see a one-unit increase in health (e.g. moving from good to very good, roughly a standard deviation increase) increases future wages by 1.3 percent, or an elasticity of 0.05. This effect is small, and solely driven by the interaction between wages and health. Comparing healthy to unhealthy workers we find in Table 2 that the marginal effect of an extra hour of work has a larger payoff for unhealthy workers, while the opposite is the case for an extra improvement in health.

In the middle of Table 1 we see very high persistence in health capital. Time and money seem to have little to no effect on health, which is consistent with "flat of the curve" medicine found since the RAND health experiment of the 1970s.

The final columns of Table 1 present the utility function estimates, which point to important nonseparabilities in preferences. The estimates suggest that leisure and nonmedical spending are direct substitutes in utility, or that hours of work and nonmedical spending are complements, consistent with Shaw (1989) and Ziliak and Kniesner (2005). Although health has no direct effect on utility, the interactions between leisure and health and consumption and health suggest that leisure and nonmedical consumption are each complements with good health.

IV. Discussion

The descriptive evidence presented here shows that starting around age 35 unhealthy men have significantly lower life cycle profiles of wages and assets, which is preceded by an increase in obesity around age 30. Our model estimates show strong evidence of learning by doing, with an elasticity of future wages with respect to current hours of about 0.12. While the effect of good health on future wages is smaller, it seems to have a larger effect on the margin for already healthy men, suggesting increasing returns to good health. In ongoing research we are introducing taxation to explore more comprehensively the role of tax policy and health policy on labor-market outcomes over the life cycle via simulation of the utility function parameters. Heretofore such an analysis was not possible with prime-age workers in the U.S. for lack of credible data on hours, incomes, consumption, health, and assets in a single data source. This rich new PSID data offers many future opportunities for policy relevant research.

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