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Why do people demand health?

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Abstract

This paper proposes several ways to extend the standard model for health and health services. Psychological aspects such as status seeking, identity seeking and health adaptation are modelled within the framework of the Grossman model. While the two first aspects may be important psychological mechanisms, the adaptation process seems to be the most relevant process to model within a theoretical dynamic framework. As far as we know, there are no formal analyses of this process in the economic literature.

1. Introduction

In economic literature, the standard model for the demand for health and health care is the Grossman model (Grossman, 1972). In this model, health is considered as a capital stock which may be increased due to investment in health (buying health services or spending time on healthy activities), while it will be depreciated due to, e.g., age. There are two reasons why individuals demand health, according to the model. First, health is a *consumption commodity* in the way that it directly enters the individual preference or utility function. Good health implies higher utility than bad health for a certain consumption level. For instance, a depressed person will not gain as much utility from a good meal as he would if he was not depressed. The second reason to demand health is based on health as an *investment commodity*. Health determines the total amount of time available for market and non-market activities, e.g., the ability to earn money. Bad health gives more sick days than good health, days that cannot be used to the mentioned activities. Thus, better health increases the available time, which can be measured in a monetary value. This may be thought of as a return to investment in health. In addition to the two mentioned reasons to have a good health, the stock of health is also essential to determine the length of life. When the stock reduces to a certain level, the minimum health level, life terminates.

Grossman's insightful work has been followed up by several theoretical studies (e.g., Cropper, 1977, Wolfe, 1985, and more recently in Erlich and Chuma, 1990, Ried, 1998, and Eisenring, 1999), but the main structure of the model has been kept.

There have also been several empirical studies of the Grossman model. Zweifel and Breyer, 1997, Ch. 3, gives an overview of some of these studies. The theoretical correlations between demand for health (i.e., the health stock) and demand for medical care (i.e., the health investment) on one side and changes in health, age, education and lifetime wage on the other are compared with empirical results, both for the pure consumption and the pure investment model. The results are rather mixed, and many of the implications of the Grossman model are contradicted by available empirical evidence. For instance, for the pure consumption model, the effect of ageing on the demand from health is confirmed (negative from the theory), but the effect on demand for medical care is not confirmed (positive according to theory).

Other studies not reported in Zweifel and Breyer (1997) are Wagstaff (1993), Nocera and Zweifel (1998) and Gerdtham et al. (1999). These studies test empirically the demand for health equation derived from Grossman (1972). Wagstaff estimated demand for health equations with income, education, sex and age as explanatory variables. He estimated two equations in two separate age-groups; under and over 41 years. Age had the wrong sign (not significant) in the under 41s equation, but had the expected sign and was significant in the over 41s equation. Nocera and Zweifel (1998) estimated demand for health equations based on two panel data sets. The effects of all variables were in the expected direction in the first data set, and most variables were significant. In the second data set the results were less consistent with the demand for health model. Finally, the empirical results from Gerdtham et al. (1999) are overall consistent with the predictions of the demand for health model. The demand for health decreases with the price of medical care and with age, and increases with income and education.

As the empirical evidence to support the Grossman model is mixed, a relevant question to ask is whether the model captures all relevant aspects of individual behaviour. While the original Grossman model points out two important reasons to demand health, there may be other reasons. Findings from social psychology and related fields have for the past couple of decades been introduced into social welfare theory, to determine the individual behaviour and the demand for commodities. Three factors that may affect the welfare, utility or happiness of an individual are social status, self-expression and aspiration (for surveys, see, e.g., Ng and Wang, 1993, and Brekke and Howarth, 1998).

The individual concern for *social status* has been analysed by several authors. Veblen (1899) for instance focused on the role of conspicuous consumption in signalling social status, while Weber (1930) in contrast claimed that the ethos of capitalism grew out of a religious tradition that downplayed consumption but viewed the accumulation of wealth as a sign that individuals had found favour in God. Also human capital has been emphasised in establishing social rank through enhanced professional standing (Frank, 1985). Howarth and Brekke (1998) focus on all these aspects of status seeking to study the implications for economic growth. Hirsch (1976) connects status to the use and control of positional goods, i.e., goods and services that are defined in relation to individuals' comparative social standing. Positional goods are given in quantity and do not increase with economic growth. Examples may be to belong to the 10 per cent richest individuals in the country, to be on the national football team, to be a star in a national TV show, and to be a professor at the best university etc. In empirical studies or surveys of happiness, status seems also to play a dominant role. Such studies find that relative, not absolute, levels of income or consumption are the primary determinants of satisfaction, see, e.g., Easterlin (1996) and Hellevik (1999). Another factor that has been emphasised in happiness surveys, is *aspiration*. Reference points and aspiration levels play a very important role in determining preference or utility formation and in decision-making behaviour, see, e.g., Ng and Wang (1993), and Rabin (1998). The reference level may depend on past history, implying higher expectations and requirements to material standards in the future if current earnings increase. Thus, people may feel less satisfied with their living standard even if they are better off compared to their situation ten years before.[2] Finally, individuals may demand goods partly to express themselves, or their *identity*. If a person wants an intellectual image for instance, she may buy books and spend time to read them. Thus, goods and activities may work to symbolise identity, see, e.g. Brekke and Nyborg (1999).

[2] This is also connected to the literature on endogenous tastes, see, e.g., Elster (1979) and Sen (1987).

As the factors mentioned above might determine individual preferences and therefore the demand for commodities, they may also have consequences for the demand for health. In the same way as income, consumption, real capital and human capital, health may also work as a commodity that signals status or identity. Therefore, the aim of this paper is to present some possible factors determining the demand for health not expressed in the original Grossman model, and some ways to model these factors in economic analysis. The focus is not an in depth analysis of different model specifications. We rather present some ideas that may be further investigated in future research.

This paper is organised as follows. In section 2, we justify individual preferences determinations when health is taken into account. Section 3 briefly outlines the original Grossman model and its main results, while section 4 presents alternative model specifications under different preference determinations. Finally, section 5 discusses possibilities of future research.

2. Preference determination in health models

We will focus on three main sets of preferences in connection with health; *status*, *identity*, and a form of aspiration relevant for health analysis, namely *adaptation*[3].

Preferences may be influenced by aggregate patterns in the society. In economic models, *status* is usually expressed as a preference for being better than the average (see, e.g., Howarth, 1996, and Howarth and Brekke, 1998). One standard way of getting status in economic models is to have a higher consumption than the average person has. This may be a higher consumption level in general, or a higher consumption level of certain luxury goods. However, being young, strong and beautiful have always also been desired characteristics. Thus, at least after a certain age, humans will probably attach positive utility to these characteristics, for instance

[3] Adaptation is defined by Heyink (1993) as "…an intrapsychic process in which past, present, and future situations and circumstances are given such cognitive and emotional meaning that an acceptable level of well-being is achieved" (p. 1332). See also Groot (2000) for a discussion of adaptation in economic models.

by being considered younger and fitter than people of the same age. Good health may, therefore, also give status, and this can be specified as relative health, i.e., each person's status increase in her own health but decrease with the average health for people of the same age.

A certain *identity* can be attached to health. Being an athlete requires good health, while being a bohemian probably does not. Thus, in the same way as signalling identity via consumption of certain goods, the consumption of health services or the time spent on healthy activities may also be important for the image.[4] A female movie star who has been considered a sex symbol in her twenties and thirties may want to keep this identity when she gets older. Also, a body builder may want to keep his identity as a strong person even when he gets old. This may be specified in two ways. First, the individual prefers to have better health than a certain level, or second, the individual wants to be as close to a certain level as possible. When a person wants a certain identity, she does not compare herself to other individuals as with status, but to a certain standard.

Health is important for having a good life. This is confirmed by surveys on happiness (Hellevik, 1999)[5], and is specified as the consumption effect in the Grossman model. In this model, the only way a person can enjoy a high quality of life when the health capital deteriorates is to increase her consumption.[6] However, an individual may also have a good life when she grows older and the health naturally deteriorates. She may

[4] Good health may also have a moral value. Thus an identity as a moral person may affect the demand for health.

[5] In Hellevik (1999), a Norwegian survey on self-reported happiness, good health is one of the main determinants. Two indicators of health are used; one objective indicator, i.e., the number of doctor's calls, and one subjective indicator, i.e., self-evaluated health. Both indicators significantly contribute to self-reported happiness. Thus, this seems to be a justification for including some measure of health in the individual utility function.

[6] Empirical evidence for the UK and the US, however, show that consumption has a hump-shaped profile with a peak around age 45, see Attanasio and Banks (1998). Thus, elderly people do not compensate lower health with higher consumption.

adapt to a lower health level, given that the rate of change is not too fast.[7] Instead of enjoying skiing on Sundays, she may visit art galleries. The individual reference point changes over time as the health capital is reduced. There is, however, an asymmetry in changes of health levels, as a rapid deterioration of health may cause disutility, while a fast improvement of health may be desirable. A person who becomes blind over night will probably suffer a lot, while a blind person who gets the sight back will probably be very happy. Thus, instead of defining the level of health as an important parameter for peoples well being, the rate of change in health may be an important factor.

Based on this discussion, we propose some formal specifications for the above-mentioned preferences in section 4. The models are simplified by not considering health as an investment commodity. This does not mean that we do not believe in this

[7] Adaptation may be supported by studies on self-reported health by elderly people. In health surveys conducted by Statistics Norway, see SSB (1999), elderly people seem to consider their health as good. In the 1995 survey even if as many as 85 per cent of respondents above age 67 reported serious or less serious illnesses or worries, 58 per cent evaluated their health as good or very good, 23 per cent evaluated the health as neither good or bad, while only 19 per cent reported bad health. For people above age 80, 20 per cent reported bad health. This is a bit surprising as 27 per cent of the respondents above age 80 reported that they had an illness that strongly affected their everyday life. SSB suggests that the reason may be that health expectations are reduced when one live as long as 80 years or more. Thus, one adjusts one's expectations when one grows older. Similar results are found for people with chronic diseases. Sackett and Torrance (1978) found that patients rated the value of an impaired state of health more highly than the general public, suggesting that people with deteriorating health adapt to their health condition over time. The way of interpreting health may depend on the physical condition as well as cultural and social factors. Van Maanen (1988) reports studies among self-defined healthy American born elderly and ill-healthy British born older persons, and indicates that the perception of health was determined by many dimensions other than the absence of disease and illness. The older the person, the more emphasis was placed on health as a state of mind, even in situations of a gradually falling body. However, Rodin and McAvay (1992) found that objective illness indicators such that increases in new illnesses, increased physician visits, and worsening of pre-existing conditions, as well as psychological factors were all associated with a decline in perceived health. Thus, even if elderly people may adapt to a new situation, they may report a decreasing health state if their health actually deteriorates. Elderly people may also be more adaptive than younger people. Groot (2000) found that in a survey where people are asked about their health compared to people of their own age (age-norming), elderly people reported better health than younger people.

effect, but this effect will not be changed by the different preferences for health outlined below.

3. The reference model

As the reference model, we use the pure consumption version of the Grossman model based on the specification in Erlich and Chuma (1990). The individual maximises the discounted lifetime utility, LU, where the utility at one point of time, U, is an increasing, strictly concave, and continuously differentiable function in health, H, and consumption, C. The time preference rate is ρ, t denotes time, and T is the time of death.

(1) $LU \equiv \int_0^T e^{-\rho t} U(C_t, H_t)dt$

The stock of health can be increased by investment in health, I, which in this model refers to buying health services only, as we do not consider a time budget constraint. However, the health will be depreciated due to ageing with the depreciation rate set equal to δ_t, with $\dot{\delta}_t = \partial \delta_t / \partial t > 0$ for all t.

(2) $\dot{H}_t = I_t - \delta_t H_t$

The terminal stock of health is H_{min}, i.e., death takes place when $H = H_{min}$.[8] This gives the boundary condition $H_0 > H_{min} > 0$. Finally, the boundary constraint for the terminal stock of health is

(3) $H_t > H_{\min}, t < T$

(4) $H(T) = H_{\min}$

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[8] Alternatively, we could have a stochastic model where the probability of survival the next year depends of the health stock, see, e.g., Cropper (1977). A possibility is also to use a hazard rate approach, see Gjerde et al. (1999) for an application of this approach to global warming. This can be followed up in a health model with just minor alterations.

The individual's budget constraint is given by the following equation

(5) $\dot{A}_t = rA_t + Y_t - q_t I_t - p_t C_t$

where A is wealth, r is the market interest rate, Y is income, and q and p is the price of health services and consumption respectively. The boundary constraint on wealth is

(6) $A(T) \geq 0$

If the individual maximises (1) subject to (2)-(6), the current value Hamiltonian function to the maximisation problem is

(7) $V_t = U(C_t, H_t) + \lambda_t (I_t - \delta_t H_t) + \mu_t (rA_t + Y_t - q_t I_t - p_t C_t)$

This gives the following necessary conditions for an interior optimum:

(8) $\dfrac{\partial V_t}{\partial C_t} = U'_C(C_t, H_t) - \mu_t p_t = 0$

(9) $\dfrac{\partial V_t}{\partial I_t} = \lambda_t - \mu_t q_t = 0$

(10) $\dot{\lambda}_t - \rho\lambda_t = -\dfrac{\partial V_t}{\partial H_t} = -U'_H(C_t, H_t) + \lambda_t \delta_t$

(11) $\dot{\mu}_t - \rho\mu_t = -\dfrac{\partial V_t}{\partial A_t} = -\mu_t r$

(12) $\dot{H}_t = I_t - \delta_t H_t$

(13) $\dot{A}_t = rA_t + Y_t - q_t I_t - p_t C_t$

The transversality conditions for an interior optimum are (see Neustadt, 1976):

(14) $\lambda_T \gtrless 0, H_T = H_{\min}$

(15) $\mu_T \geq 0, A_T \geq 0$

(16) $V(T) = U(C_T, H_T) + \lambda_T \dot{H}_T + \mu_T \dot{A}_T = 0$

The costate variables λ_t and μ_t are respectively the shadow price associated with the health stock at time t and wealth at time t.

Condition (14) differs from the transversality condition used in Erlich and Chuma (1990) as they set $\lambda_T \geq 0$. The problem with this, and, therefore, also with the model of Erlich and Chuma (1990), is that it is not valid for all types of utility functions. Assume, e.g., that U(C, H) < 0 for all values of its arguments. In this case, a higher value of H_{min} will reduce the life span, T, and increase the lifetime utility. As - λ_T is the value of increasing H_{min} marginally, $\lambda_T < 0$ for this utility function. A negative value of λ_T may be the background for euthanasia. However, for the most interesting utility functions, $\lambda_T \geq 0$ probably holds.[9]

From equation (8) and (9), we find the *flow conditions* for consumption and investment in health:

(17) $p_t = \dfrac{U'_C(C_t, H_t)}{\mu_t}$

Thus, the marginal utility of consumption (measured in money units) should equal the (exogenous) price of the consumption good.

In a similar way, the marginal benefit of health investment, g, which is the money equivalent of the shadow price of health, should equal the (exogenous) price of health services.

(18) $q_t = \dfrac{\lambda_t}{\mu_t} \equiv g_t$

[9] From (16) we see that $\lambda_T \geq 0$ if and only if $U(C_T, H_T) + \mu_T \dot{A}_T \geq 0$.

Using equation (10), (11) and (18), we can derive the *stock equilibrium* condition that defines the optimal level of the health stock:

$$(19)\ \ q_t(\delta_t + r - \frac{\dot{q}_t}{q_t}) = \frac{1}{\mu_t} U'_H (C_t, H_t)$$

The left-hand side of equation (19) is the instantaneous user cost of health capital, which has a similar form as the user cost of capital from investment theory. Thus, the user cost should equal the instantaneous marginal benefit of increasing the health stock with one unit. This is also called the "marginal efficiency of capital".

Finally, we can derive the explicit expression for the shadow price of health using equations (18) and (19):

$$(20)\ \ g_t = e^{-\int_t^T (\delta_\tau + r) d\tau} g_T + \int_t^T e^{-\int_t^\tau (\delta_s + r) ds} \left[\frac{1}{\mu_0} U'_H (C_\tau, H_\tau) e^{(r-\rho)\tau} \right] d\tau$$

Using the expressions from Ehrich and Chuma (1990), the first component on the right-hand side is the "value of life extension" which is the discounted value of the terminal health stock measured by its shadow price. This may be positive or negative due to the transversality condition (14). The second expression on the right-hand side is the "value of a healthy life", which is the discounted health benefits accruing over the remaining life span. This is always positive.

Using comparative dynamics, we can find the impacts on important endogenous variables due to shift in exogenous variables. There are, however, several difficulties in doing comparative dynamics in a model in continuous time with more than one stock variable. The method of path analysis proposed by Oniki (1973) can only be used in a model of one stock variable, see also Eisenring (1999). Using Frisch decision functions as in Ried (1998) is only possible in a model in discrete time. Thus, the best way of doing a comparative analysis may be to study the effects in a numerical model. This means that some of the results derived in theoretical papers may actually be wrong. However, the following results derived from Ehrlich and

Chuma (1990), Table 3, Zweifel and Breyer (1997), Table 3.2, and own model simulations, seem to hold for the pure consumption version of the Grossman model.

Table 1: Comparative dynamic analysis of the reference model[a]

	A_0↑	H_0↑	q↑	δ↑	ρ↑	Y↑
T	+	+	-	-	-	+
H	+	+	-	-	-	+
I	+	?	-	?	-	+

Source: Ehrlich and Chuma (1990), Zweifel and Breyer (1997), own model runs.

[a] + means that the partial derivative is positive, while – means that it is negative.

4. The alternative models

a) Status models

We will specify two ways an individual may gain social status. The first is via consumption, and the second is via health. In the case of *consumption*, we assume that each person's status increases with her own consumption, but decreases with the average consumption of society, $\overline{C}$. Thus, in this case the lifetime utility is:[10]

$$(21)\quad LU \equiv \int_0^T e^{-\rho t} U(C_t, \frac{C_t}{\overline{C}_t}, H_t)dt$$

Maximising (21) subject to (2)-(6), yields the following condition for optimal consumption:

$$(22)\quad p_t = \frac{U'_C(C_t, \frac{C_t}{\overline{C}}, H_t) + U'_{\frac{C}{\overline{C}}}(C_t, \frac{C_t}{\overline{C}}, H_t) \cdot \frac{1}{\overline{C}}}{\mu_t}$$

[10] A critique of this way of modelling status may be that status is already an attribute of the utility function, and the relative consumption should not be specified as an additional argument. However, we follow the specification in Howarth (1996) and Howarth and Brekke (1998).

Consumption gives an additional utility effect via relative status, implying a higher optimal consumption compared to the reference model. Due to the budget constraints (5) and (6), the investment in health, and, therefore, the health stock will be lower.

If *health* yields status instead of consumption, the lifetime utility may be specified as below, where $\overline{H}$ is the average health of people of the same age:

$$(23)\ LU \equiv \int_0^T e^{-\rho t} U(C_t, H_t, \frac{H_t}{\overline{H}_t})dt$$

The stock equilibrium condition from maximising LU subject to (2)-(6) is:

$$(24)\ q_t(\delta_t + r - \frac{\dot{q}_t}{q_t}) = \frac{1}{\mu_t}\left[U'_H(C_t, H_t, \frac{H_t}{\overline{H}_t}) + U'_{\frac{H}{\overline{H}}}(C_t, H_t, \frac{H_t}{\overline{H}_t}) \cdot \frac{1}{\overline{H}_t}\right]$$

As the last term in the brackets is positive, the individual gets an extra utility gain from investing in health, namely the status effect. Thus, as the budget is given, this individual will have a higher health capital, and consume less than in the reference model.

They way status is gained has implications for people's health. Being materially concerned will reduce the person's health, while being concerned about look or fitness will increase health. In general, in the same way as rent-seeking behaviour, relative status-seeking behaviour leads to a dead-weight loss for the society, as people tend to overinvest in goods giving status, i.e., consumption status gives an inefficiently high consumption and health status gives an inefficiently high health. The number of people who can enjoy high status is limited, and buying status goods may only lead to a redistribution of status within the society. Therefore, status creates a negative externality. One person's increase in consumption or health will reduce other people's well being. From economic theory, goods that create negative externalities should be taxed. Thus, taxes on consumption should be increased if high consumption creates status, see, e.g., Howarth (1996). However, the policy implications when status is created by health are different for two reasons not included in our model. First, as mentioned in the introduction, health is also an investment commodity, that increases the consumer's available time. As the person may spend some of this time at work, the income may increase due to better health, and, therefore, consumption does not necessarily decrease. Second, even if a person's better health may impose a negative externality on other people, a bad health imposes a negative externality on other people via the governmental budget. A bad health condition in the society means that a larger share of the budget goes to social security and public health care, leaving a lower share of the budget for other public services. [11] Also the public income may be reduced if less people work due to bad health. Thus, the increase in public health condition due to status seeking may, therefore, increase social welfare instead of decreasing it, as will be the implication of other status-seeking activities.

Including status in a health model will, however, not change much of the dynamics of the reference model and a static model may probably be appropriate to analyse the effects of status.

b) Identity models

If a person prefers to have *better health than a certain level*, $\hat{H}$, to keep her identity, the lifetime utility function can be specified as follows:

$$(25)\ LU \equiv \int_0^T e^{-\rho t} U(C_t, H_t, H_t - \hat{H}) dt$$

We assume that the person will gain positively from an even higher level of health than $\hat{H}$, e.g., being even more beautiful or stronger. The maximisation problem yields the following stock equilibrium condition:

$$(26)\ q_t(\delta_t + r - \frac{\dot{q}_t}{q_t}) = \frac{1}{\mu_t}\left[U'_H(C_t, H_t, H_t - \hat{H}) + U'_{H-\hat{H}}(C_t, H_t, H_t - \hat{H})\right]$$

[11] An effect in the opposite direction is if health care demand increases as a result of people having better health. E.g., an athlete demands more health services than an average consumer does.

The gain from an increased identity implies a higher investment in health than in the reference model, and, therefore, a higher health stock.

If the individual wants to be as *close to a certain level* as possible to keep her identity, e.g., a jazz musician who does not want to appear too athletic, we may introduce her identity function (see Brekke and Nyborg, 1999):

(27) $S_t = -(H_t - \hat{H}_t)^2$

The person wants a health as close to $\hat{H}$ as possible. Worse as well as better health may not give the desired identity. The desired level may change over time. Thus, the lifetime utility takes the following form

(28) $LU \equiv \int_0^T e^{-\rho t} U(C_t, H_t, S_t) dt$

From the optimisation problem, the stock equilibrium condition for health investment is

(29) $q_t(\delta_t + r - \frac{\dot{q}_t}{q_t}) = \frac{1}{\mu_t}\left[U'_H(C_t, H_t, S_t) - 2(H_t - \hat{H}_t) \cdot U'_S(C_t, H_t, S_t)\right]$

While the first term in the brackets on the right-hand side shows the direct benefits of increasing the health capital, the second term shows the effect on identity. If $H > \hat{H}$, the increasing health yields a disutility via the identity function, while it is the other way around if $H < \hat{H}$. Whether the person will have a higher or lower health stock than in the reference model depends on $\hat{H}$.

In the same way as for status models, the dynamics will not be changed very much compared to the reference model. Thus, a static model seems to be appropriate to analyse the effects of identity.

c) Adaptation model

The dynamic framework seems to be more important if we want to analyse the effects of adaptation. If the individual is able to fully adapt to the new health level and, therefore, maintain her quality of life, her lifetime utility can be written as follows:

(30) $LU \equiv \int_0^T e^{-\rho t} U(C_t, \dot{H}_t) dt$

As a deterioration of health implies a disutility and a health improvement increases utility, we have $\partial U(C_t, \dot{H}_t) / \partial \dot{H}_t > 0$. It seems reasonable to assume that $\partial^2 U(C_t, \dot{H}_t) / \partial \dot{H}_t^2 < 0$.

The current value Hamiltonian from maximising (30) subject to (2)-(6) is as follows:

(31) $V_t = U(C_t, I_t - \delta_t H_t) + \lambda_t (I_t - \delta_t H_t) + \mu_t (rA_t + Y_t - q_t I_t - p_t C_t)$

This gives the following necessary conditions for an interior optimum:

(32) $\frac{\partial V_t}{\partial C_t} = U'_C (C_t, \dot{H}_t) - \mu_t p_t = 0$

(33) $\frac{\partial V_t}{\partial I_t} = U'_{\dot{H}} (C_t, \dot{H}_t) + \lambda_t - \mu_t q_t = 0$

(34) $\dot{\lambda}_t - \rho \lambda_t = -\frac{\partial V_t}{\partial H_t} = -(U'_{\dot{H}} (C_t, \dot{H}_t) \cdot (-\delta_t) - \lambda_t \delta_t)$

(35) $\dot{\mu}_t - \rho \mu_t = -\frac{\partial V_t}{\partial A_t} = -\mu_t r$

(36) $\dot{H}_t = I_t - \delta_t H_t$

(37) $\dot{A}_t = rA_t + Y_t - q_t I_t - p_t C_t$

The transversality conditions for an interior optimum are:

(38) $\lambda_T \gtreqless 0, H_T = H_{\min}$

(39) $\mu_T \geq 0, A_T \geq 0$

(40) $V(T) = U(C_T, \dot{H}_T) + \lambda_T \dot{H}_T + \mu_T \dot{A}_T = 0$

The individual takes into account that the health stock, H, affects the lifetime via the transversality conditions.

The flow condition for investment in health is:

(41) $q_t = \dfrac{U'_{\dot{H}}(C_t, \dot{H}_t) + \lambda_t}{\mu_t} \equiv h_t + g_t$

where $h_t = \dfrac{U'_{\dot{H}}(C_t, \dot{H}_t)}{\mu_t}$, i.e., the money equivalent of the marginal utility from a change in $\dot{H}$.

We see that if λ_t is negative, a necessary condition for an interior optimum is that $U'_{\dot{H}}(C_t, \dot{H}_t) > \lambda_t$.

The *stock equilibrium* condition that defines the optimal level of the health capital is given as

(42) $q_t(\delta_t + r - \dfrac{\dot{q}_t}{q_t}) = h_t(r - \dfrac{\dot{h}_t}{h_t})$

From (41) and (42) we find

(43) $g_t(\delta_t + r - \dfrac{\dot{g}_t}{g_t}) = -\dfrac{1}{\mu_t}\delta_t U'_{\dot{H}}(C_t, \dot{H}_t)$

As the right-hand side of (43) is negative, the user price of health (the left-hand side) also has to be negative. Thus, there are two possibilities: 1) g < 0, i.e., the shadow price of health is negative, or 2) $\dfrac{\dot{g}}{g} > 0$ and $\dfrac{\dot{g}}{g} > (\delta + r)$, i.e., the shadow price of health is increasing and is larger than the sum of the depreciation rate and the market interest rate. (This may be a possible solution, see Erlich and Chuma, 1990.)

The shadow price of health may be deduced from (43):

$$(44)\ g_t = e^{-\int_t^T (\delta_\tau + r)d\tau} g_T - \int_t^T e^{-\int_t^\tau (\delta_s + r)ds} \left[\frac{1}{\mu_0} \delta_t U'_{\dot{H}} (C_\tau, \dot{H}_\tau) e^{(r-\rho)\tau} \right] d\tau$$

The second component (the value of a healthy life) is negative as a marginal increase in H increases depreciation and therefore reduces $\dot{H}$, giving a disutility to the individual. This is in contrast to the reference model. Thus, the sign of g is dependent on the sign of g_T, i.e., whether the value of life extension is positive or negative. A higher stock of health may contribute negative to the lifetime utility of the individual.

One problem with this model is that the individual does not take the health history into account. One alternative is, therefore, to specify a health variable, K, which is a weighted sum of all changes in the health stock. Thus, the individual also considers earlier changes in health when evaluating her health situation today. The K function may be specified by the following relationship based on Hoel and Isaksen (1994):

$$(45)\ K_t = \frac{H_0}{1+\beta} + (1+\beta) \int_0^t e^{-\beta(t-\tau)} \dot{H}_\tau d\tau, \beta \geq 0$$

β is a non-negative adaptation parameter. It can be shown that if β = 0 we get $K_t = H_t$, and that $\lim_{\beta \to \infty} K_t = \dot{H}_t$. Thus the utility functions in (1) and (30) are special cases of the function U(C,K) where K is specified in (45).

5. Discussion and conclusions

This paper has discussed several ways to extend the Grossman (1972) model to take into account different aspects on human behaviour emphasised in social psychology and related fields. We have particularly focused on aspects such as status seeking, identity seeking and health adaptation.

The theoretical results from the Grossman model, i.e., the demand functions for health and health services, have been tested empirically by several authors. The results from these studies are, however, rather mixed. One reason may be that the Grossman model does not take into account several aspects of human behaviour such as mentioned above. Other reasons may be lack of good data or that the comparative dynamics of the theoretical model do not seem to be sufficiently executed in some studies. In addition, the effects of changes in exogenous variables on the demand for health services are not always clear, and may change with age. Often, some simplifying assumptions have to be made to get unambiguous results, see, e.g., Ried (1998).

Also, in empirical studies, an important problem is the unobservability of health capital. In most studies, measures of health have been constructed on various health indicators, such as various health problems and symptoms (see, e.g., studies reported in Zweifel and Breyer, 1993, and the two studies by Wagstaff, 1993, and Nocera and Zweifel, 1998). Gerdtham et al. (1999), however, used quality-adjusted life-years (QALYs) as an outcome measure. This is a measure of health developed in the field of economic evaluation of health-care programs. However, this is a subjective measure of health; it is based on people's own evaluation of health. Thus, QALY's count for adaptation, e.g., elderly people may report higher QALY's than expected because they have adapted to their falling objective health. It is interesting to note that the study using QALY's as a measure of health seems to report a better consistence with the theory than studies trying to rely on more objective measures of health.

Adaptation seems to be the psychological process that is most relevant to analyse within a dynamic framework such as the Grossman model. There are several reasons for this. First, status seeking and identity seeking does not seem to change the qulitative aspects of the model very much, and may be better studied in a more simple static framework. Second, adaptation is a dynamic process where past experience may influence the present health evaluation. Third, there seems to be much more empirical evidence on health adaptation than on the other processes discussed in this paper.

Thus, a study of adaptation seems to be a natural following up of this survey. As far as we know, there are no formal analyses of this process in the economic literature.

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