MG_4.DOC June 17, 1998

HOUSEHOLD PRODUCTION OF HEALTH INVESTMENT

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ANALYSIS AND APPLICATIONS

Allen C. Goodman*

Miron Stano**

John M. Tilford***

June 1998

* Department of Economics, Wayne State University
** Department of Economics, School of Business Administration, Oakland University
*** Department of Pediatrics, University of Arkansas for Medical Sciences

JEL Category: I12

Address communications to Allen C. Goodman, 2145 FAB, Wayne State University, Detroit MI 48202; Phone: 313-577-3235; FAX: 313-577-0149; e-mail: agoodman @ econ.wayne.edu

We are grateful to Kevin Cotter, Sean Durkin, Michael Grossman, Kathy Hayes, and three anonymous referees for helpful comments and suggestions. Goodman is partially supported by Grant DA10828 from the National Institute on Drug Abuse (NIDA), and by a grant from The Blue Cross-Blue Shield Foundation (BCBSF) of Michigan. The usual disclaimer applies.

HOUSEHOLD PRODUCTION OF HEALTH INVESTMENT:
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Abstract

Michael Grossman's health investment model provides significant insights into allocations between both leisure and income, and health and non-health goods. Though widely cited, the sophistication of Grossman's work has obscured some of its more important implications. Our article develops a geometric extension of Grossman's pioneering work and applies it to a wide range of analyses in which the allocation of time is important. By integrating the labor-leisure choice with the consumer's production of both health and non-health goods and distinguishing between medical expenditures and health care investment, our approach provides a convenient framework for analyzing the effects on health care demand and health investment of a rich set of exogenous variables. In addition to income and wage effects, the model examines the effects of alternative insurance arrangements including managed care, travel times, waiting times and schooling. Through the relative resource intensities in the production of health and non-health goods, we also develop an alternative approach to resolving observed differences between the income elasticity of demand for health goods and health investment.

Key words: Health investment, Medical expenditures

HOUSEHOLD PRODUCTION OF HEALTH INVESTMENT: ANALYSIS AND APPLICATIONS

Grossman (1972a, 1972b) demonstrated how the economic valuation of time could be extended into a powerful examination of the allocation of time and money to the production of health. By building on Becker's (1965, 1971) seminal contributions on human capital, Grossman recognized that the consumer demands health, rather than medical care *per se*. Thus medical care is a derived demand from health investment. Furthermore, health is not purchased passively in medical markets. Instead, in the Becker tradition, consumers actively produce health by combining medical inputs with time spent on health-improving activities. Similarly, unlike standard demand theory, the consumer does not derive utility directly from purchases of other market goods. Consumers combine non-medical market inputs with leisure time to produce consumption goods and activities or home goods (e.g. baking bread).[1]

Although his work remains a standard in health care analysis, the richness of its implications tends to be overlooked (Cutler and Richardson, 1998). Originally formulated with calculus, Grossman's model and various theoretical extensions (e.g., Muurinen, 1982, Zweifel and Breyer, 1997) have been inaccessible to a wide range of professional economists and students alike. Alternatively, many graphical interpretations have been so simplified as to hide some of the more important conclusions. For example, Rapoport, Robertson, and Stuart (1983) derive the demand for health services, but do not consider either the labor-leisure tradeoff or the allocation of time to the production of health care. Olsen (1993) extends a model previously developed by Wagstaff (1986) that distinguishes between health and health care, but it does not recognize the time inputs that are needed to produce both health and non-health goods.

This paper develops a geometric model that retains Grossman’s central features and applies it to a wide range of analyses in which the allocation of time is important. Although Grossman emphasized the intertemporal nature of health investment, many aspects of the demand for health and/or health care services are appropriately treated in a single period model. After we develop our model, we show how income effects for health services and health investment depend on whether the production of health is

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1 Grossman recognized that improved health has consumption and investment qualities. As consumption, it makes us feel better. As investment, it provides the opportunity to work more hours, more years until retirement, or more productively, either in the market or in the home.

relatively resource or time intensive. We continue with applications to other variables placing special emphasis on the effects of alternative insurance arrangements including managed care.

THE MODEL

The single period presentation requires consumers to trade leisure time for income to be spent on market inputs consisting of *medical* inputs (from hospital stays to over -the-counter products) and *home* inputs (all non-medical inputs in a two-good model). Market inputs together with time are needed to produce health investment and home goods. By assuming that the consumer's utility is a function of the amounts of health investment and home goods that are produced in the period, consumers must make the following simultaneous decisions:

- Allocation of time to labor (and by implication, income) and leisure;
- Production of health capital through health investment, and production of other goods, i.e. the home goods;
- Purchases of market health inputs to be used in the production of health capital and other market inputs, to be used in the production of home goods;
- Determination of health investment that will address the long term individual needs regarding health capital.

A Two Quadrant Framework

Our geometry describes the optimization process through a Two Quadrant approach shown in Figure 1. Solution values are indicated with asterisks.

(Figure 1 - Equilibrium in Two Quadrant Model)

The consumer optimizes between health investment I on the X-axis, and home good C on the Y-axis. Given a well-behaved utility function in Quadrant I, he or she chooses a labor-leisure combination allowing the purchase of medical inputs M and home inputs B, and allocating time to health activities T_h, home activities T_b, and $work = 24 - T_h - T_b$. We will show how the production possibilities are derived to provide a unique Quadrant I equilibrium.

Resource constraints and production are derived in Quadrant II that indicates a standard labor-leisure tradeoff with respect to the allocation of time to wage-earning activities. The X-axis reflects time constraints, and the Y-axis reflects market inputs, either medical or home inputs, that can be purchased through the income earned from market work. Unearned income or transfer payments, reflecting pure income effects, can be indicated as upward shifts, at the maximum level of time (e.g. 365 days per year, or 24 hours per day). Assuming no days are lost to illness, in equilibrium the consumer chooses how many hours to work and how much income G^* to earn for spending on either medical or home inputs.

Quadrant II also indicates how health is produced. The consumer's resource constraints can be modeled as an Edgeworth Box. The box width indicates the amount of leisure remaining after the allocation of time between work and leisure. The box height indicates the dollars G^* of income that were earned. Amount G^* is divided between medical inputs M and home inputs $B = (G^* - M)$. The amount of money spent on medical inputs is measured downward from G^*; the remainder is spent on expenditures for home inputs.[2]

The isoquants in the Edgeworth Box are mapped in opposite directions (with health investment = 0 in the "northwest corner" and home good production = 0 in the "southeast corner"). The contract curve indicates that any change in the allocation of time and market inputs to the production of the two goods must decrease the production of one of the goods.[3]

We show below that the outcomes of qualitative analyses depend on the relative intensities of the two processes. Unless otherwise noted, we will assume that the relative market prices of health market inputs and home inputs, as well as wage rates are constant. Without loss of generality, we will begin by assuming that health investment is more market intensive (less time intensive) than is the home good. Differential factor intensities with either constant or decreasing returns to scale are sufficient to provide a

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2. Our treatment of the Edgeworth Box, following Bator (1957), considers an endowment of wage income and leisure time. At the outset, we normalize the prices of home inputs and medical inputs each to 1, so that quantities reflect expenditures. We relax this assumption later.

3. Although all of these variables are determined simultaneously, this aspect can be considered as follows. Given optimal G^*, the consumer maximizes utility with respect to health investment I, and home good, C, allocating M and T_h such that:

$$\max U\,[C\,(G^* - M, T^* - T_h), I\,(M, T_h)].$$

The optimum with respect to the marginal products of the production functions is the tangency of I and C isoquants.

production trade-off that is bowed outward from the Y-axis. While this is obvious with decreasing returns to scale, note that under constant returns to scale, if the two goods have the same factor intensities at any two points, they must have them everywhere (only then yielding a linear production trade-off). We assume constant returns unless otherwise noted, and Appendix A outlines a more formal proof that the production possibilities curve (*PPC*) is always outward-bowed under constant returns.

We recognize that time and market goods are complements for some health investment activities and substitutes for others. Niacin tablets, which reduce cholesterol levels, substitute for time-consuming exercise. In contrast, cholesterol tests require time-consuming visits to the clinic. However, in a two-dimensional framework, it is essential only that the factor intensity of health investment differs from the factor intensity of home production (otherwise, there is no distinction between the two goods).

Equilibrium

Assume that the consumer has chosen a large amount of leisure, and thus has little earned income as shown by the horizontal Edgeworth Box (dashed lines) in Quadrant II. Since health investment *I* is market intensive, the consumer would be able to produce only a small amount of it, although considerable amounts of home good *C*. It is likely that more *I* (and less *C*) would increase utility so that the consumer, as in Figure 1, will move "northeast" up the income-leisure trade-off. Each point on the leisure-income line provides a box, and a corresponding *PPC*. In Quadrant I, we show only the *PPC* corresponding to the box determined by *A*, and the production possibilities frontier *PPF, i.e.* the outer envelope of these *PPCs*. The utility-maximizing consumer chooses optimal levels of I^* and C^* at point *A*.[4]

Quadrant II indicates how I^* and C^* are produced. From the derivation above, Point *A* (Quadrant I) implies a unique Edgeworth Box in Quadrant II with dimensions G^* and T^*. Moving down the Y-axis from G^* shows the amount of medical inputs M^* to be combined with leisure T_h^*, to produce health investment I^*. The remainder of time $T_b^* = T^* - T_h^*$, and the remainder of expenditures $B^* = G^* - M^*$, are combined to produce home good C^*.

This analysis shows clearly that the optimal amounts of health investment and home goods depend

4. Deaton and Muellbauer (1980) show that the *PPF* is concave to the origin. Muellbauer (1974) derives conditions (constant returns, non-joint production) under which the *PPF* is linear.

both on production *and* on preferences. Suppose that the consumer had preference function U^{**}, valuing the home good relative to health investment. Point A would not be efficient. Since by assumption health investment is relatively market intensive, the consumer could choose more leisure (and less income), producing less investment, with the resulting equilibria at points A_1 and A_1' respectively.

The construction of the production trade-off is logically separable from the individual's utility function. Thus one may be able to produce health investment efficiently yet not "value" it very much, or vice versa. This implies that the demands for leisure and medical inputs depend jointly on the ability to produce *and* the utility derived from consumption.

Although this presentation does not explicitly address the intertemporal aspects of the Grossman model, it can be used to consider them. Health investments are reflected through successive snapshots of this model. Earlier, we ignored "sick time." Suppose, however the consumer has typically been unable to work (i.e. unable to produce either market goods or home goods) 10 days per year due to illness. Relabeling the X-axis in days, this implies an X-intercept at 355 days, rather than 365 days. Thus an increase in health capital may yield an outward parallel shift in the opportunity locus of Quadrant II.

The consumer can calculate the investment level I_h that would maintain the health capital stock at a constant level over time, but I_h may not be the same as the optimal investment I^* in the given period. If $I^* > I_h$, net health capital rises; if $I^* < I_h$, it falls. The wage rate, or slope of the trade-off, may also be related to the level of health capital. If $I^* > I_h$, increased productivity might be modeled as an increased wage rate.

COMPARATIVE STATICS

This section examines the comparative statics properties of the model, beginning with pure income effects, leaving relative prices constant. It then shows the importance of the relative factor intensities of home and health investment production. It ends by considering wage effects which combine the pure income effects with substitutions away from the now more expensive leisure.

Income Effects

Figure 2 shows an increase in nonwage income. The initial equilibrium point A in Quadrant I has (home good/health investment) ratio $(C/I)_0$, produced with (market input / leisure) ratio $(G/T)_0$, noted in Quadrant II. The increase in nonwage income shifts the budget line in Quadrant II and the production possibilities frontier to PPF_2 in Quadrant I.

(Figure 2 - Income Effects)

If the new equilibrium has the same Quadrant II (*G/T*) ratio, the optimal (*C/I*) ratio remains the same in Quadrant I (where $(C/I)_0$ intersects PPF_2) due to the constant returns to scale assump-tion. With the *given* (non-homothetic) utility function, however, increased production of health investment at the expense of the home good provides a Pareto superior improvement. With mar-ket intensive health investment, this implies taking a greater percentage of the increased income in market goods than in leisure, at point A_1', in Quadrant II and equilibrium point A_1 in Quadrant I.

With the stronger preference toward (market intensive) health investment, the increased income translates into a high demand elasticity for medical inputs and for health investment. If the consumer has a stronger preference for the time intensive home good, he or she will take the increased (wage + unearned) income in more leisure time. Here the increased nonwage income translates into modest (if any) increase in total income, and a lower demand elasticity for health investment. The lower elasticity is determined jointly by the production technology (Quadrant II) and the taste for health investment relative to the home good.

Factor Intensities

This result depends directly on the factor intensity of producing health investment and the home good. If the home good was market intensive relative to health investment, an increase in (wage + unearned) income would permit the production of more home good relative to health investment. Under such circumstances the increased income would translate into a low demand elasticity for medical goods and for health investment because of the production technology.

Estimates of demand elasticities at the individual or market levels indicate that health care is a necessity. In contrast, income elasticities from cross-national studies typically exceed unity, suggesting that health care is a luxury.[5] By distinguishing between health and health care, Olsen (1993) describes how health care may be a luxury at the same time that health is a necessity.

(Figure 3 - The Importance of Factor Intensity)

Our model provides further insight into this controversy. Consider Figure 3. Assume first, as above, that the production of health is relatively market intensive and that the initial equilibrium is at *A* in Quadrant I, and at A' in Quadrant II. The initial expenditure on medical inputs is M^*, and the interior optimum in Quadrant II is at point a'.

Consider now an increase in income as drawn in Quadrant II. At the implicit price ratio P_I / P_C, there would be an increase in health investment, and actually a decrease in home good production, noted at the point where ray $(C/I)_R$ intersects the market intensive *PPF*. This is a familiar result from international trade theory. If health investment is market intensive, then an increase in market goods (with no increase in time) more than proportionally increases the output of health investment (the market intensive good), and decreases the output of the home good.

This is an example of the Rybczynski Theorem from international trade. Following Ethier (1995), consider a *k%* increase in market goods with no increase in home production time. Outputs of home good and health investment cannot both increase by *k%*, because this would require *k%* more leisure time as well. With an increase in market goods, leisure time now becomes more productive if producing health investment. Total leisure time has not changed, but the production of health investment has increased and so increased its use of the fixed amount of leisure time. Therefore, with an increase in market goods, the market intensive health investment must increase by more than *k%* and the output of the home good at the constant factor prices and output shadow prices must actually fall. Appendix B presents this result mathematically.

With the given utility function, however, the consumer optimizes with relatively less health investment, and more home good, at point A_1. This can be seen in Quadrant II as well; at the initial implicit price ratio, the consumer would move to the circular point *X* on the new contract curve joining the

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5. See, for example, Newhouse (1977), Parkin et al (1987), and Gerdtham (1992).

origin to A_1'. The reduced demand for health investment moves the equilibrium along the new contract curve to point a_1' where expenditures are M^{**}. Although health investment production exhibits constant returns to scale, the new equilibrium is more market intensive than the initial one. Since the time input will not increase as fast as the market input, it is quite likely that health care will be a luxury even though health investment (and hence health itself) is a necessity. The income elasticity of health investment demand can be measured through the difference in investment indicated by (A_1 - A), induced by the increase in income.

This result incorporates the one established by Olsen. However, by excluding production time for both health and home goods, Olsen's model ignores the possibility of obtaining just the opposite result. If the production of health is relatively time intensive, the demand for health in-puts will increase more slowly than income. This is a move from point A to A_2 in Quadrant I, with the dashed *PPF* reflecting the more time intensive production process. Thus the demand for health inputs, as well as health investment, will have income elasticities less than +1 (except in the unlikely case of highly increasing returns to scale in the production of health investment).

Wage Effects

It is well known that the effect of an increased wage rate on the demand for health investment cannot be determined *a priori* (Acton 1975). There are two effects: (1) an income effect increases the ability to produce goods that are market intensive; (2) an increased opportunity cost of time reduces the demand for time intensive products. These effects depend on the relative resource intensities of the two production functions.

Excluding time inputs from health investment and health care demand analyses severely limits the range of results. In addition, once time inputs are recognized, the issue of whether the production of health is relatively resource or time intensive requires further exploration.[6]

(Figure 4 - Income and Substitution Effects)

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6. Willis (1973) examines economic theories of fertility using a presentation (the allocation of resources between children and non-children) related to ours. On the basis of other work cited in that article, he assumes that children are the more time-intensive of the two goods.

The distinction between wage and nonwage incomes can be emphasized by considering an increase in the wage rate and hence wage income, holding (the increased level of) utility constant (Figure 4). One can derive an isoutility curve at utility level u^{**} for Quadrant II that is directly related to the utility function in Quadrant I. This is done by tracing a set of coordinates of income and leisure commensurate with utility level u^{**} in Quadrant II (the identical levels of utility in income-leisure space). This utility curve is related to the difference in the marginal rates of substitution and the marginal rate of transformation from Quadrant I.

Assuming no nonwage income, one can calculate the wage rate necessary for the consumer to reach the isoutility curve u^{**}. This is shown by the dotted income-leisure line in Quadrant II that is just tangent to u^{**} at point A_2'. The equivalent change in nonwage income is shown by a parallel shift in the initial income-leisure line to one that is just tangent to u^{**} at point A_1. An increased wage rate implies that leisure is relatively more expensive; hence, the consumer takes less of it. The resulting increased wage rate leads to a "thinner" box (not shown), a higher ratio of resources to leisure (commensurate with the higher cost of leisure), and, because health investment is market intensive, relatively more production of health investment, as noted in the dashed line in Quadrant I. This distinction between wage and nonwage income also demonstrates the conventional income and substitution effects, with wage income (making leisure more expensive) leading to more production of the market intensive good.

OTHER EFFECTS

Travel Time

Our analysis addresses the impacts of travel (or waiting) times on the demand for health care inputs. Travel time breaks the link between the levels of time and market resources and the amounts available for home production. Assume for simplicity that travel has zero out-of-pocket costs, but positive time costs each time medical services are required. This assumption implies that production of health capital must become more time intensive. A unit of health investment that previously required t_h now requires time $(t_h + t_t)$, where t_t refers to travel time per unit.[7]

7. If considering *daily* allocation of time, with the choice between no medical care and some medical care, one diminishes the width of the production box in Quadrant II by the amount of time necessary to

(Figure 5 - Impact of Time Costs on Health Production)

We ignore Quadrant I since an increase in time costs will rotate the *PPF* inwards and the new equilibrium, under most conditions, will have lower levels of both health investment and the home good. Because the same amount of medical inputs now requires more time to produce a given level of health investment, the new contract curve in Quadrant II becomes more time intensive (where time includes *both* leisure and travel time), as noted by the solid curve. This production change implies that the Quadrant II curve relating health investment to medical expenditures must be more time intensive at all levels of production.

We begin with the initial equilibrium *D*, showing the ratio of medical inputs to health time of $(M/T_h)_0$. To maintain the same level of *I*, with necessarily less *C*, the imposition of travel costs rotates the factor intensity ray to $(M/T_h)_1$, or to point *E*.

However, the decreased demand for both *C* and *I* (due to the inward shift in the *PPF*) moves the equilibrium to reduced production of both. New equilibrium point *F* shows:

- increased time spent on health ($T_h^{**} + T_t^{**}$), but decreased time ($T_h^{**} < T_h^{*}$) spent producing it;
- decreased medical expenditures ($M^{**} < M^{*}$);
- increased inputs to the home good, $B^{**} > B^{*}$, but $T_b^{**} < T_b^{*}$, such that $C^{**} < C^{*}$.

These analyses indicate that the travel time impact depends on the consumer preference pattern, the magnitude of the travel time relative to income, and the price of medical inputs. Suppose that the consumer values health investment relatively highly compared to the home good. This implies that in response to an increased opportunity cost of health investment, the consumer will maintain health investment close to I_1^{*} (close to point *E*).

Changes in the production of health investment and the home good may occur independently of the consumer's wage rate. Thus using the wage rate alone to proxy the valuation of travel time may not

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travel or wait. The consumer has fewer time resources available to produce either of health investment or the composite good. The impact is an unambiguously more resource-intensive production of health investment.

be justified.[8] Moreover, wage rate changes enter the *health resources - investment* relationship in a complicated manner, particularly if travel time itself (e.g. bus *v*. taxi or private transportation) is related to the wage rate.

Health Insurance and Managed Care

Our framework also provides a convenient outlet for investigating impacts of health care insurance and managed care. We begin with the premise that a consumer is offered an insurance policy such that the gross wage remains constant. That is, the dimensions of the Edgeworth Box in Quadrant II remain the same, holding wage and income effects constant package in lieu of a wage increase. The first example will involve a fee-for-service indemnity plan offering a constant percentage coinsurance rate such that the consumer gets ***a*** dollars ($\boldsymbol{a} > 1$) of medical expenditure coverage for each dollar out-of-pocket. This means that for any dollar value of *M*, the amount of health investment must increase.

(Figure 6 - Impact of Health Insurance)

Beginning from initial equilibrium point *D*, suppose that the implementation of insurance raises ***a*** from 1 to 2 (reducing the coinsurance rate from 100% to 50%). One could purchase the exact same amount of medical inputs for $M^*/2$, the "thin" isoquant, with an equilibrium at *D¢* noted as I_0^* *(shifted)*. However, since the marginal cost of medical inputs is now half the previous level, the isoquant (in dollar space) must be steeper, drawn as I_0^* *(rotated)*. The new contract curve goes through the rotated isoquant at *D¢¢*.

The reduced cost of health investment indicates that the consumer is more likely to purchase both more *I* and more *C*. In Quadrant II we see that he or she moves down the new contract curve to equilibrium point $I_1^* > I_0^*$ (with $C_1^* > C_0^*$), or from point *d* to point *e* in Quadrant I. Out-of-pocket expenditures have fallen from M^* to M^{**}, although total health expenditures have risen from M^* to $2M^{**}$.

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8. Numerous authors use the wage rate as a valuation for time costs regarding health care. See Colle and Grossman (1978), Goldman and Grossman (1978), Sindelar (1982), Coffey (1983), and Mueller and Monheit (1988). Tilford (1993) analyzes willingness to pay (WTP) for a reduction in doctor's office waiting time as an alternative measure of the opportunity cost of time. Using WTP to measure the opportunity cost of time reduces the income effect, which may confound empirical analyses of time price elasticities. See De Vany (1975) for a discussion of these issues.

Recalling that one dollar of medical expenditures now buys the consumer two units of medical inputs, we find point *E¢*, indicating *2M***. The ray through *E¢* indicates that the consumer has moved to a more market intensive production of health investment. Because out-of-pocket resources have been "freed up," point *E* represents a more market intensive production of the home good as well. This occurs because market goods, in particular health insurance, have been subsidized relative to leisure time.

The moral hazard that characterizes traditional insurance is indicated by the increase in medical care spending from *M* to 2M***. Employers and employees may view health care spending at 2*M*** as unacceptable, and may be willing to consider alternative delivery forms, such as managed care, that reduce their premiums. As a result of rapidly rising health care costs and premiums, managed care has grown from 10 million HMO subscribers in 1981, to the point where by 1995 three-fourths of all employees with employer-provided coverage were enrolled in HMOs and other managed care plans (Jensen, et al 1997).

Managed care refers to a system that relies on financial incentives and management controls, such as treatment protocols, disease management and coordination of services, to reduce the levels of moral hazard and inappropriate care (Stano, 1997). It is commonly associated with capitation and risk contracting under which insurers and/or providers are paid a fixed amount per beneficiary per month to provide all covered services. Because these plans or providers assume the risk for overspending that amount, they have strong profit motives to limit care and substitute less expensive for more expensive forms of care.

The empirical evidence is consistent with this hypothesis. Managed care plans contain costs by substituting outpatient care for inpatient care and, more generally, by adopting less expensive treatments (Miller and Luft, 1994, 1997). It has also been argued that, on account of high patient disenrollments, managed care plans have incentives to substitute maintenance and continuing care for treatments for treatments with high up-front costs when alternative treatments are available (Stano 1996).

To compare the effects of capitated managed care with traditional indemnity insurance in our model, start once again at equilibrium point *D*, and presume that the individual pays 50% of a given monthly premium in a capitated managed care plan. Assume that the patient has no out-of-pocket costs at the point of service (HMOs in particular have minimal cost sharing features), but that the patient surrenders autonomy over the level of services to be rendered.[9] Of course the patient will form expectations about the level of services of any particular managed care plan.

If the amount of care remains at *2M***, then the equilibrium is the same as the indemnity insurance case. Through its incentives and controls, and its fundamental objective of eliminating “unnecessary care,” it is likely that the plan selected will reduce the level of medical goods to points between *D″* and *E*, or an amount less than *2M***. Assume that the consumer expects the amount of health care shown at *F* under this plan. Furthermore, assume that the patient has a choice of managed care plans with 50% coinsurance on the monthly premium, where there is a continuum of available plans (and premium) that vary in direct proportion to the level of expected health spending (within the limits of *D″* and *E*). Thus health care is still being subsidized relative to leisure time in the same manner as above so that the individual will optimize along the same contract curve as before.

If, in order to reduce moral hazard and health care premiums, the consumer selects the managed care plan that provides medical care at point *F*, the capitated plan (compared to the indemnity plan) will result in:

- lower production of health investment;
- more goods intensive production of health investment, because the labor, with less medical care to work with, will be more productive in the home good.
- less time spent producing health investment.[10]

These results conflict with assertions that managed care plans promote health investment, but our analysis explicitly holds both tastes for health investment and health investment production functions constant. To

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9. The demand for managed care can also be viewed as a response to imperfections, particularly consumer information and agency problems, that create inefficiencies in traditional indemnity insurance markets. We abstract from these complex issues by assuming a given level of services. We also abstract from the wide variety of managed care arrangements that have emerged.

10. Although the contract curve is the same as before, managed care enables individuals to par-ticipate in a “club” that limits moral hazard and corresponding premiums. If a consumer wishes to buy more medical care than *F*, or if *F* represents a ceiling on the amount of *M* subsidized by the employer, the consumer can buy additional care at the unsubsidized market price. This creates a kink in the *PPF* in Quadrant I, as the opportunity cost of health investment abruptly increases.

the extent that managed care changes tastes or production efficiency, consumers may devote more time, and more medical goods to health investment.

If reduced medical care is also accompanied by increased waiting or travel time in managed care systems (due, for example to tighter scheduling and less conveniently located sites), the analysis from Figure 5 indicates that the health investment isoquants would shift to the right. This would lead to a less goods-intensive technology, although some of the time spent in health production would be waiting and travel time rather than productive time.

Education, Technology, and Medical Expenditures

The model can also clarify a considerable literature on the impact of education and/or schooling on health care.[11] The literature identifies two effects of schooling. The first is an increased efficiency in the production of health investment. The second is a change in preference for health investment relative to other uses of resources (e.g., improved exercise, better eating habits, less consumption of alcohol or tobacco).

Modeling increased efficiency of health investment production depends on the characterization of technological change. Referring back to Figure 1, if Hicks-neutral change is assumed, then Quadrant II contract curves remain the same, with the isoquants relabeled. Quadrant I presents an outward shift. Depending on preferences, the increased allocation both to health investment and to the home good, may come with no increase, and possibly a decrease, in medical expenditures.

A change toward a "healthier life style" might lead to a less steeply sloped expansion path (i.e., locus of tangencies) for Quadrant I preferences. Hence, increased schooling may imply a greater taste for health investment, at the same time that fewer resources are needed. Examining the equilibrium shows how these changed tastes may increase medical expenditures through increased health investment. Moreover, the analytical framework indicates how the two effects of schooling, in principle, may be distinguished from each other.

CONCLUSIONS

11. See Grossman (1972a, 1972b), Fuchs (1982), Wolfe and Behrman (1987), Berger and Leigh (1989), and Behrman and Wolfe (1989).

By treating the labor-leisure choice and the purchase of health care inputs in a unified setting, our model extends Grossman's pioneering insights, and makes them more accessible for a wide range of policy analyses. Despite our simplification and synthesis of Grossman's work, however, the analysis remains rich and complex. In particular, our model emphasizes the importance of factor intensity and preferences regarding consumer demand for health care inputs in the production of health investment.

Factor intensity plays a key role in several applications. Contrast low and high wage earners, for example. Both are endowed with 24 hours of leisure per day. Therefore, if health investment is relatively time intensive, the investment opportunities in health capital may be similar for those in either group (although the low wage earners would have much less of the home good). If, however, health investment is relatively market intensive, high wage earners, with more opportunities to purchase market goods than low wage earners, will be able to combine more market goods with their leisure time. In this case, factor intensity may exacerbate wage rate inequality into further inequality in health investment.

Both the labor-leisure trade-off and the relative technologies of health and (other) goods production must be addressed in empirical work. There is a considerable current interest, for example, in substituting home care (a time intensive alternative) for nursing home expenditures (a market intensive technology). An economic analysis of this policy must compare the increased capital costs of nursing homes with the increased opportunity costs of home caregivers.

As we have shown, our model further clarifies the distinctions between the expenditure elasticities for health expenditures and health investment (as discussed by Olsen, 1993). Our approach also indicates the importance of carefully specifying time costs and home production technology in conducting research on the effects of travel, and waiting times on health care demand and health investment.

Finally, we offer some tentative insights on insurance and managed care. Our analyses show that if tastes and/or health production technologies are held constant, the reduced levels of health expenditures (compared to indemnity plans) produce reduced levels of health investment. Managed care will increase the amount of health investment only if it changes tastes for health investment, or the technology or efficiency for producing health investment.[12]

12 The questionable record of HMOs' emphasis on health promotion is consistent with our model. For example, Donelon, Blendon, Benson et al. (1996) found that "sick patients in managed care plans were no more likely than patients in fee-for-service plans to report that their doctors reminded or urged them to get preventive services." (p. 263)

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Appendix A

The Production Possibility Set Under Constant Returns to Scale

Following Quirk (1976), maximize health investment I subject to home good $\bar{C}$:

$$\mathcal{L} = I\,(T_h, M) + \lambda\,[\bar{C} - C\,(T^* - T_h, G^* - M)].$$

First order conditions lead to:

$$dI/dC = \lambda < 0.$$

For the production set to be convex (bowed outward) under constant returns to scale, it is necessary that $d\lambda/dC < 0$. Denoting factor intensity of health investment as k_I, in constant returns function $i(k_I)$, and the home good as k_C, in constant returns function $c(k_C)$, it is easily shown that:

$d\lambda/dC < 0$ if and only if $k_I \neq k_C$

Thus, strict convexity occurs if and only if the factor-intensities differ for two goods. If $k_I = k_C$, that is, factor intensities are the same, $d\lambda/dC = 0$, and the curve is a straight line.

Appendix B

The Impact of Changing Factor Proportions

Following Findlay (1970) assume constant returns to scale, so coefficients a_{gI} and a_{tI} denote the goods and time per unit of health investment output I. Coefficients a_{gC} and a_{tC} denote the goods and time per unit of home good output, C.

These coefficients will vary with the relative factor prices (time with the wage rate, and the home good with the out-of-pocket market good price), but at given commodity price (e.g. health investment relative to the home good) and factor price ratios, the coefficients will be constants.

Denoting the total amounts of goods and time available as G and T respectively these equations indicate that all of the goods and time available are used to produce I and C.:

$$a_{gI} I + a_{gC} C = G, \text{ and}$$

$$a_{tI} I + a_{tC} C = T.$$

Dividing both equations by T, and solving for I/T and C/T yields:

$$I/T = [a_{tC}(G/T) - a_{gC}] / (a_{gI} a_{tC} - a_{tI} a_{gC})$$

$$C/T = [a_{gI} - a_{tI}(G/T)] / (a_{gI} a_{tC} - a_{tI} a_{gC}), \text{ or}$$

$$I/C = [a_{tC}(G/T) - a_{gC}] / [a_{gI} - a_{tI}(G/T)].$$

This provides the ratio of commodity outputs as a function of the goods/time ratio.

Differentiating (I/C) with respect to (G/T):

$$d\,(I/C) / d\,(G/T) = (a_{gI} a_{tC} - a_{tI} a_{gC}) / [a_{gI} - a_{tI}\ (G/T)]^2.$$

Then:

$$d\,(I/C) / d\,(G/T) \gtrless 0 \text{ as } a_{gI} / a_{tI} \gtrless a_{gC} / a_{tC}, \text{ where:}$$

a_{gI} / a_{tI} is the (goods/time) ratio for health investment

a_{gC} / a_{tC} is the (goods/time) ratio for the home good.

If income rises (implying higher G), and if health investment is goods-intensive, then (I/C) must rise. With T constant, for I to rise, some time must be taken away from home production, so B must fall in absolute terms. For further discussion of this effect, see Krugman and Obstfeld (1997).

Our analysis also covers out-of-plan care. If a consumer wishes to buy more medical care than is provided at *F*, or if *F* represents a ceiling on the amount of *M* subsidized by the employer either under managed care or fee-for-service, the consumer can buy additional care at the unsubsi-dized market price. Figure 7 illustrates how the increased real income implicit in the health care subsidy shifts out the Quadrant I production possibility frontier (*PPF*). There is a kink in the *PPF* at point *f*, as the opportunity cost of health investment abruptly increases. The kink does not necessarily imply that *f* is an equilibrium, since the consumer may choose $I^*_c > I_f$, at point *g*. From this, one can calculate the additional "out-of-plan" expenditures borne by the consumer under capitated treatment.[1]

1. The Quadrant I equilibrium level of expenditures would be described by yet another Edgeworth Box with dimensions determined by the remaining time and the remaining money, given the levels of time and money already used through the capitated plan. It would provide needless complication to the analysis.

Figure 1 - Equilibrium in Two Quadrant Model

Health is resource-intensive. Production technologies and preferences jointly determine the amount of leisure, amount of work, and purchases of medical inputs and home inputs.

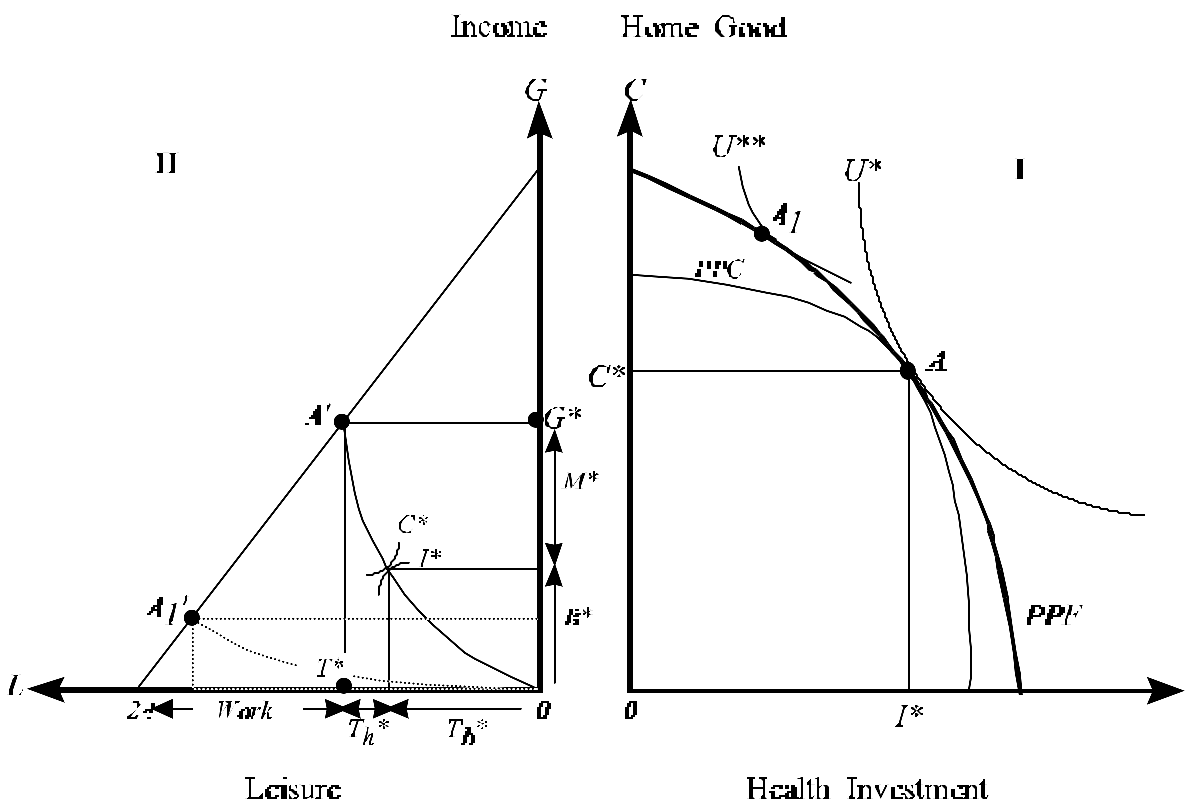

Figure 2 - Income Effects

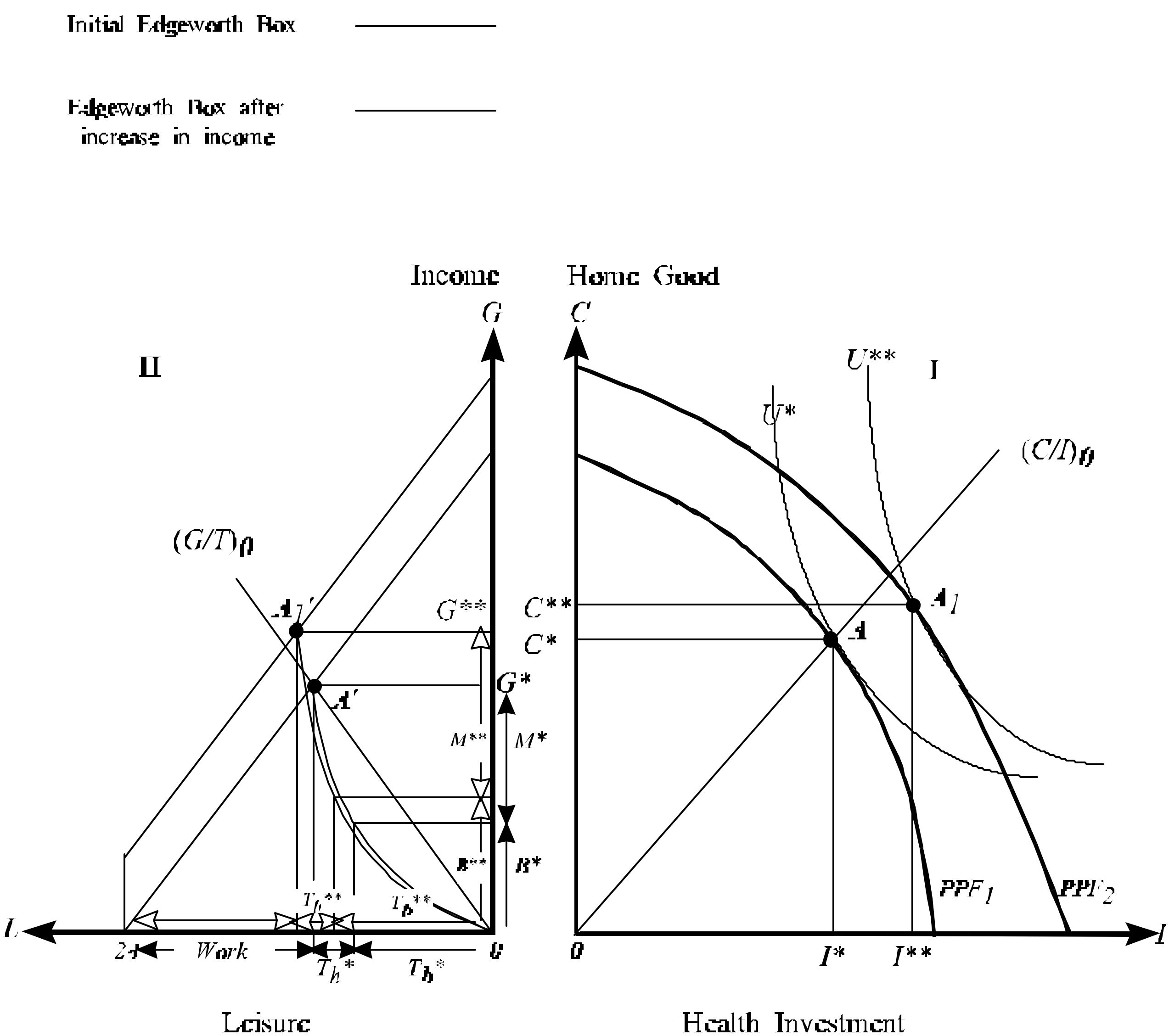

Figure 3 - The Importance of Factor Intensity on Demand for Medical Care and Health Care Resources

Initial contract curves	———— (solid)	Health investment is market intensive
	········ (dotted)	Health investment is time intensive
Contract curves after increase in income	———— (solid)	Health investment is market intensive
	········ (dotted)	Health investment is time intensive

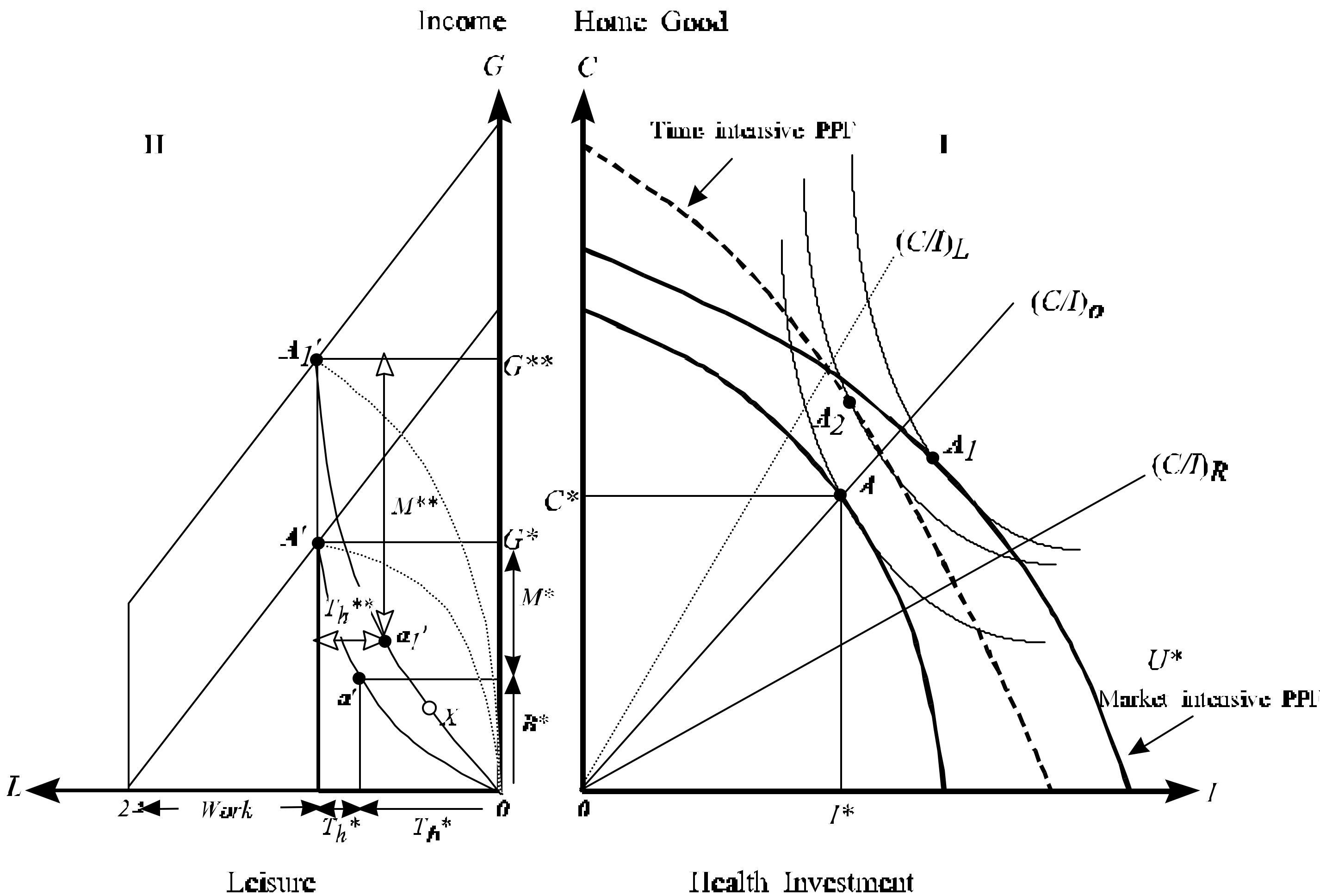

Figure 4 - Income and Substitution Effects

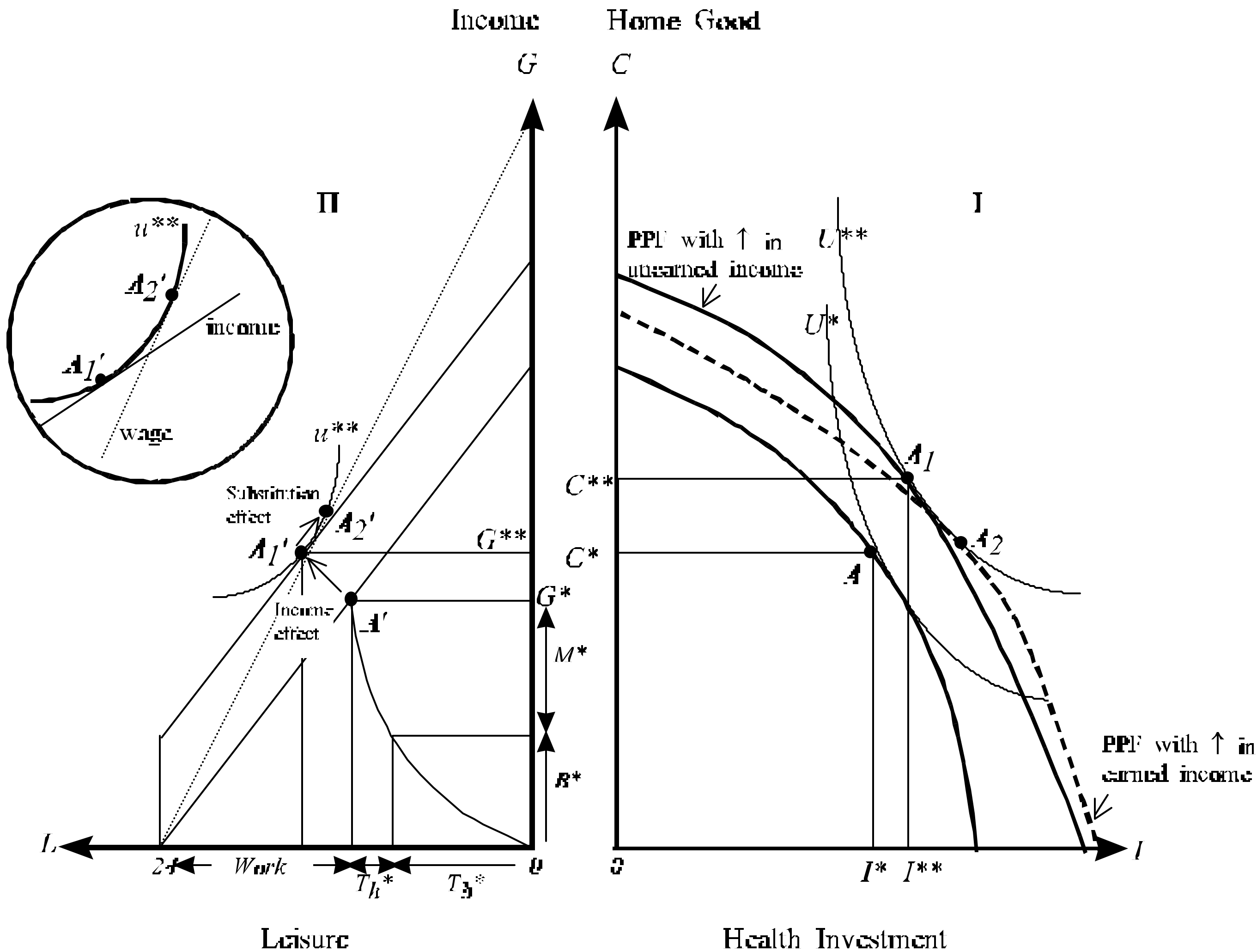

Figure 5 - Impact of Time Costs on Health Production

I_0* represents initial isoquant

I_1* represents same level of output as I_0*, but with increased time costs

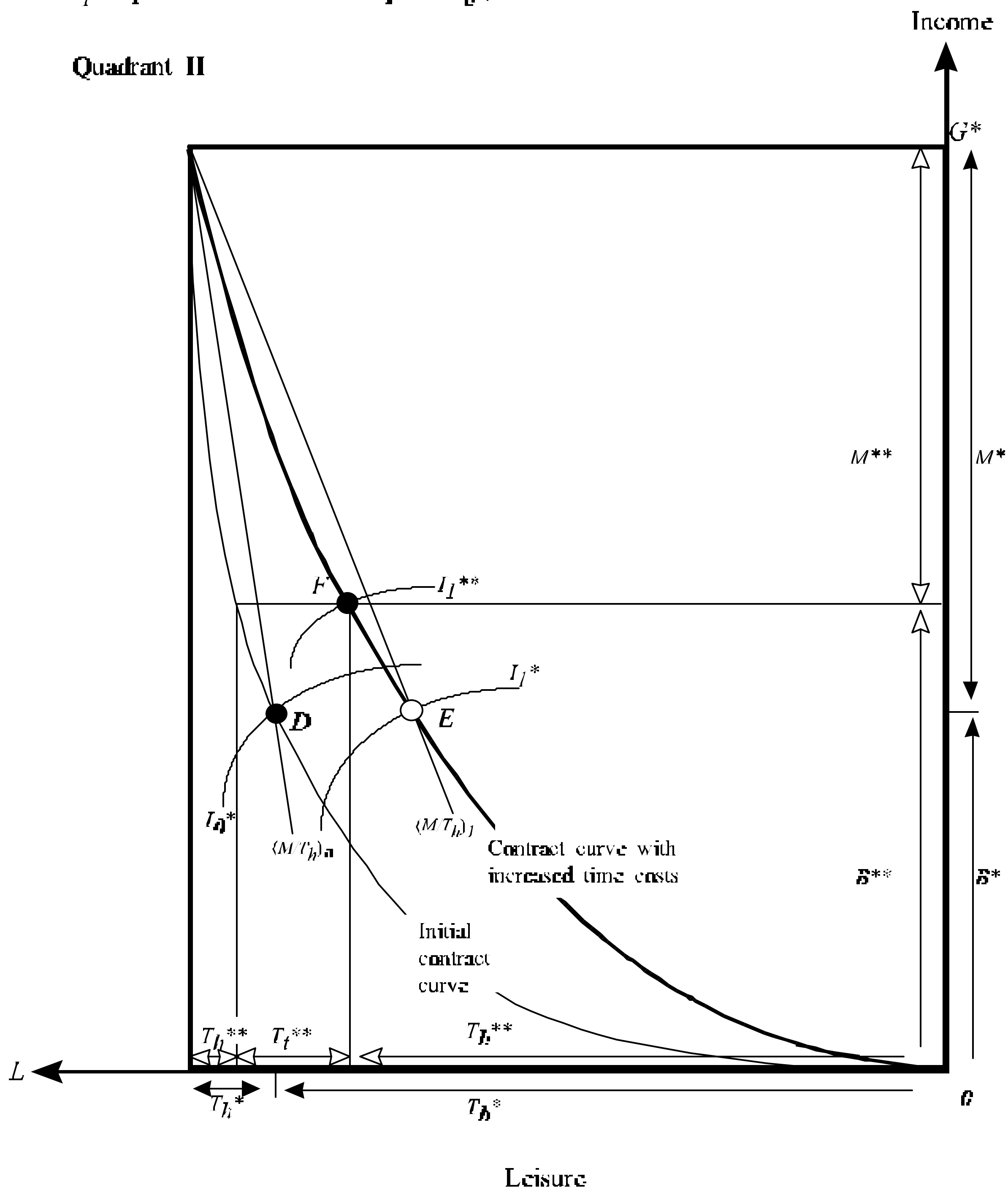

Figure 6 - Impact of Health Insurance