A New Theory of Health and Consumption

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In this paper, Ryan Cleary proposes an original model for consumers' decisions when deciding how much to spend on healthcare rather than other forms of consumption. While most of the literature is based on the idea of healthcare as a part of human capital, Ryan offers a new view of health's effects on consumption, which illustrates the channels through which health spending affects utility. In conclusion, he proposes a reconciliation point between the two separate views of health from the consumer and health as a form of capital in order to understand the consumption decision of healthcare.

Much of the theory regarding decisions on health expenditure is derived from Michael Grossman's influential paper "On the Concept of Health Capital and the Demand for Health". This paper considers health as a part of human capital. People have a stock of health, which they then must maintain over the course of their lives through expenditure on healthcare. The treatment of health in this model is like other forms of human capital, such as a skill. People must maintain health to be fit to work, as they must maintain their skills to perform their work.

This way of viewing health has created its own branch of literature in the past decades (See Wagstaff, 1986, 1993; Jacobson, 2000). The work of Grossman has been the leading way of viewing health, however, as shall be argued, it only views health as a form of capital, and this is an incomplete view. The purpose of this paper is to develop a new model of health expenditure decisions facing individuals. It shifts the focus of health as a form of capital to health as something that affects utility. People improve their health, and this underlies the enjoyment of the rest of their consumption. Health, in this way, is more than a simple consumer good and this requires a special treatment.

Significance

This model deviates from the previous literature in its focus on health's relationship with utility. If someone is healthy, this model assumes he or she will enjoy life much more than if he or she were not. Beginning with the idea of health affecting utility, the rest of the model emerges to illustrate the consumption trade-offs for individuals. Health (or more appropriately, demand for health) will enter this model through spending on healthcare, which is simplified into a premium. This could be considered, for example, as a premium for health insurance.

Simple Model: Health and Length of Life

The first of the 2 models (summarised in Appendix A) which will be developed is a simple exposition of this model which is needed to illustrate the core ideas, establishing the groundwork needed to understand the more complex model. A person chooses their premium and consumption based on their lifetime income, which is known. Their expenditure on the premium affects the length of their life.

Assumptions

Length of Life

The representative person lives for L years if they remain disease-free.

Illness

This model will use a representative illness, which is contracted by a proportion, r, of people in the society.

$$0 < r < 1$$

The r people who contract the disease lose λ years of life. This means the representative person in a world before treatment the following determines life length:

$$Periods\ lived = (1-r)L - r(L-\lambda) = L - r\lambda$$

Given that the disease will be contracted by a proportion of r people, (1−r) people will live the full L years.

Treatment

Treatment will be represented by variable T. If the agent becomes ill, they receive treatment based on the level of premium they selected. Treatment is a function of the premium. $T_{(P)}$ represents the number of periods gained back if a person gets sick. $T_{(P)}$ is related positively to P. Formally this is written as

$$\frac{dT}{dP} > 0$$

The more money a person spends on their healthcare, (P) the more effective their healthcare is. This means that those who contract the illness see a reduction in the years they lose. The following condition is imposed for simplicity:

$$\lambda > T_{(P)}$$

Alternatively, the loss of life from having the disease is higher than any recovery by treatment. This assumption means L is the upper limit on life. Someone cannot spend money on their Premium and extend their life years beyond L. This assumption is not crucial, but it simplifies the calculation and still allows the intuition to be displayed without the complicating cases of people extending their lives beyond L. This leaves the following expression for the length of life:

$$Years\ lived\ with\ health\ spending = (1-r)L + r(L + T_{(P)} - \lambda)$$

The person will live for L years with probability (1 – r). They contract the illness and lose λ years of life with probability r. In the event they do contract the illness, they regain $T_{(P)}$ years of life. As an aside, if

$$T_{(0)} = 0$$

This means if someone does not spend money on the health, they see no increase in their life in the event they become ill. If $T_{(0)}$ was some positive number, then this could be considered the social minimum healthcare offered through government or access to free clinics. This is not the case here, for simplicity, but it is not difficult to conceptualise and could have interesting implications for voting for socialised medicine and health spending vs consumption.

Money

A person has a budget of M. They can spend money on two things; consumption goods or the health. They will spend all their money in their lifetime. In this way, the following is true:

$$C + I = M$$

Income is simplified in this model and is equal to M. M represents a smoothed income in each period and C and P represent smoothed consumption and health expenditure in each period, as per the Permanent Income Hypothesis.

A person's income expenditure is governed by the Euler Equation where:

$$u'(c_t) = \beta^{t+1}u'(c_{t+1})(1+r) = \ldots = \beta^{t+n}u'(c_{t+n})(1+r)$$

$$for\ simplicity, \beta = 1 \text{ and } r = 0$$

$$u'(c_t) = u'(c_{t+1}) = \ldots = u'(c_{t+n})$$

$$which\ implies$$

$$c_t = c_{t+1} = \ldots = c_{t+n} = C$$

A level of C is not needed in every period because it smoothed. A single C, the smoothed value of consumption, is used in the model. This simplifies the effects of transitory income, such as retirement.

Utility

Simplifying consumption will lead to utility from consumption being Log(C). This means that, before we add in the length of life, Utility will be:

$$U = Log(C), which\ means\ U'(c) = \frac{1}{C} > 0\ and U''(c) = -\frac{1}{C^2} < 0$$

The first order condition means changes in income have a positive effect on utility, and the second confirms diminishing marginal utility. Now we multiply the log of consumption by the length of life lived. Consumption smoothing will be in effect, so the person's utility will be the consumption each period multiplied by the number of periods:

$$U(C,P) = Log(C)[(1-r)L + r(L + T_{(P)} - \lambda)]$$

OR

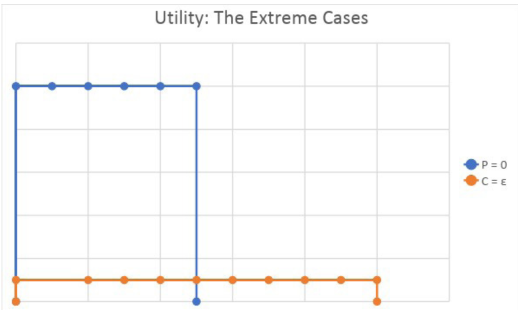
$$U(C,P) = Log(C)[L + rT_{(P)} - r\lambda)]$$

And the agent will maximise this subject to:

$$C + P = M$$

Interpretation

If an agent only consumes and does not pay for health, they will live for L – rλ years and the highest consumption, but the lowest possible life length. By sacrificing some consumption, they increase their years lived but have little consumption, and little utility, in each period. The following stylised graph illustrates this:



In this graph, when P = 0, life is short however each period gives high utility. In the case where C = ε, and ε is small and positive, life stretches much further with each period granting little utility. The agent seeks to maximise the area under this curve, which is found geometrically. The same optimisation sentiment holds true with the following, more complex, model. This example has laid down the framework.

Model 2

Quality of Life

Up until now, Quality of Life is assumed constant throughout the agent's life. Therefore, the graphs given previously are angular. Quality of life, and utility, decline over time. People's quality of life is assumed to depreciate and their ability to experience joy depreciates as they age. For example, a young person would likely enjoy a cricket game much more than an older person who may struggle with deteriorating eyesight. The item they consume is the exact same at the same cost, but the younger person's experience will be better due to their higher quality of life.

Representing Quality of Life

To represent the progression of quality of life graphically, a type of equation must be chosen. For this analysis, the cubic equation has been selected as the closest representation of quality of life.

Mechanically, this will follow the following sort of system, using just an (x,y) space.

$$-x = y^3$$

Where x and y correspond to their corresponding axis. This will give the graph as presented above. Bringing this into the model, we replace x and y with what they represent in this model: Time and Quality of Life respectively.

$$-t = \text{Quality of Life}^3$$

Where the lower-case t represents time in this model. Lower case is used to differentiate time and the Treatment from earlier.

Intuition

Initially a person will have a relatively steady quality of life, which will decline with age. As they age, they suffer general deterioration. Very often an event will happen which will drastically deteriorate the person's health. This could be a heart attack, a stroke, or car crash. This could even be something less severe, and then the downwards kink may be very gentle.

After the event, either the person will die, or they will continue to live at a much lower quality of life level. Their quality of life will then continue to deteriorate for the general wear and tear reasons as before. In this world, death is assumed to occur when quality of life becomes 0.

Factoring Quality of Life Into the Equation

In this case, a person will still seek to maximise their utility through consuming and living a long life, but now quality of life is also factored into the utility equation. This is done in the same way as length of life.

- A person who does not contract a disease will live with a Quality of life of q.

q is a function of time, with the condition that:

$$\frac{\partial q_{(t)}}{\partial t} < 0$$

- Or that quality of life declines over time as a person ages.
- Those who contract the disease will lose a quality of life equal to δ.

The insurance will return a quality of life of w, and this is a function of the premium P. As with treatment,

$$\frac{\partial w_{(p)}}{\partial P} > 0$$

Or that the return to quality of life depends positively on the premium.

The more the agent pays, the more quality of life will be returned to them.

Quality of life will then be standardised by dividing it by q. This ensures that it is between 0 and 1.

$$Quality\,of\,Life = \frac{q_{(t)} - r\partial + rw_{(p)}}{q_{(t)}}$$

By dividing by q, a person with no chance of getting sick will live with a quality of life of 1, which represents a full quality of life. Any illness will then alter this to be a number between 0 and 1, representing a lower quality of life. Furthermore, this cannot be negative. To make this negative would imply a negative quality of life, and the person would die by construction.

In the event that a person were to live without becoming sick, then r = 0, which gives 1. This represents a full quality of life. q itself is a function of time, representing the deterioration of health, and therefore enjoyment of life, before death. If someone does get sick, his or her quality of life suffers based on δ, or the degradation caused by illness. They recover quality of life according to w, which is a function of P. For simplicity, "security" is not considered in this model. People do not feel anxious for not choosing a high P, nor do people with a high P feel more secure and thus in better health without the worry.

Now that we have an expression for the quality of life, we can factor this into the model. A reduced quality of life will "dampen" the utility from consumption. It is because of this, it enters the equation as the coefficient of consumption. Finally, in this model, we have already established the intercept, which is the point of death. Mechanically, this enters on the right-hand side as it has been written previously.

We are left with this following equation:

$$-x = Log(C)(\frac{q_{(t)} - r\partial + rw_{(p)}}{q_{(t)}})^3 - [L + rT_{(P)} - r\lambda]$$

This follows the pattern of

$$-x = ay^3 - c$$

Which is needed to give the graphic form as depicted above. Breaking up the parts of the equation illustrates the role each plays.

$-x$	Time. The x-axis.
a	$Log(C)$, the coefficient of the y variable.
y	$\frac{q_{(t)} - r\partial + rw_{(p)}}{q_{(t)}}$ The y variable which is quality of life. A function of time.
c	$L + rT_{(P)} - r\lambda$ The intercept of the x axis. Represents the point of death, when quality of life is equal to 0.

Maximising Condition

Just as in the simpler example given previously, the agent seeks to maximise the area under the curve. Whereas the previous example had a simple geometric solution of length times height, this solution requires an integral.

Maximise

$$U(P, C) = \int_0^{L + rT_{(P)} - r\lambda} (Log(C)(\frac{q_{(t)} - r\partial + rw_{(p)}}{q_{(t)}})^3 - [L + rT_{(P)} - r\lambda]dt$$

Breaking down this integral, the function being maximised is the curve established earlier. The maximisation point starts at

$$t = 0$$

and this continues until

$$t = L + rT_{(P)} - r\lambda$$

This, as has already been established, is the length of the life. t = 0 can be considered birth and life runs until death, which was obtained from the previous model.

Constraint

As before, the agent is limited by money. Their income is assumed to be known. The individual chooses levels of P and C. These must be equal to their total income. It is assumed that the individual will spend all their income. This results in:

$$C + P = M$$

What we have now is the following:

$$Maximise\ U(C,P) = \int_0^{L+rT_{(P)}-r\lambda} Log(C)\left(\frac{q_{(t)} - r\partial + rw_{(p)}}{q_{(t)}}\right)^3 - [L + rT_{(P)} - r\lambda]dt$$
$$subject\ to\ C + P = M$$

Through this, it is possible to see the interactions between the variables and the channels through which the choice variables and others affect Utility and, ultimately, the Consumption decision.

The best way to understand this model is to break it into its constituent parts; namely, the length of life equation, which appears as the intercept and the utility, gained from consumption, which is effected by quality of life.

The term r appears in both parts, and represents the proportion of people who contract the illness.

$$\frac{\delta(Length\ of\ life)}{\delta r} = T_{(P)} - \lambda$$

This means that if r increases, more people get the disease. This decreases the years someone expects to live given a level of P, which makes sense given that they are more likely to become sick. It also increases the benefits of T, as T is now more likely to be needed. For the representative agent, there is a greater reward to T given that r increases as it will recover more years of life should they become sick, which is more likely.

A very similar result is obtained when calculating using quality of life, which shows as r increases, representative quality of life declines but there is a greater return to w. This method of breaking apart the model into its constituent parts works well to illustrate the dynamics for any variable.

Interpretation

If the person increases spending on P, then Log(C) falls. This will lower utility due to the restriction that C + P = M. An increase in P necessitates a fall in C. P appears twice in the equation. W and T are functions of P. By increasing spending on P, the agent will have a higher quality of life as $w_{(p)}' > 0$ and they will live longer as $T_{(P)}' > 0$. By living longer and experiencing a higher quality of life, the person will see an increase in their utility.

This suggests a balance between consumption and health expenditure is desirable, and there exists a balance, which maximises utility. Diminishing marginal utility prevents favouring only one of the two goods to the complete neglect of the other, in most cases. Eventually there will come a point where the agent would rather extend their life over consuming more, or vice versa.

Given that, this is a utility equation whereby the objective function is U(C,P), the optimality condition will be given by

$$U'(C) = U'(P)$$

The marginal gain in utility from increasing consumption is equal to the marginal gain in utility from increasing health spending.

Final Extension

The model still has scope for further development to deal with the limitations, which currently exist within the model. Income itself is related to well -being. Income is treated as exogenous above, however it could be incorporated into the model through developing the budget constraint to be dependent on health.

Conclusions

The model presented displays the interaction between the various variables in question. It not only illustrates how changes in expenditure affect utility of the agent, but also crucially illustrates the exact channels through which these changes occur, which is not something which has been illustrated previously. This is a necessary paper as it represents another element of health, which has not been considered in the literature thus far. The seminal paper in this area considered health to be a form of human capital.

This is a valid view of health; however, it is quite narrow and ignores the relationship between utility and being healthy. By viewing health as a good itself, the above model challenges the way people perceive health. It is not just capital to be maintained, but rather something which fundamentally alters the way we experience consumption.

The limitations of this model, specifically income's relationship to health, provide scope for further development of this model. If done, this model would become a more complete model of healthcare and consumption, taking both the income and quality of life effects health has on overall utility. This paper does however illustrate the relationship between health and utility derived from consumption. Understanding this mechanism is important if we wish to truly understand the decisions agents face regarding health spending. I hope that by approaching the question in a unique manner, this paper has contributed to our understanding of how health-spending decisions are, and should be, made.

Reference List:

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Appendix A

Model 1: Summary

The agent lives for L years. The agent contracts a representative disease with probability r, which will reduce their life by λ years.

The agent spends money on health and consumption, P and C, which must equal their budget, M.

Treatment is a function of the health expenditure and can partially offset their loss should they become ill.

People maximise their length of life times their consumption, or:

$$\text{Maximise } U(C,P) = Log(C)[L + rT_{(P)} - r\lambda]$$

Subject to:

$$P + C = M$$

Appendix B

Model 2: Summary Length of Life is determined as above, quality of life is no longer held constant. Quality of life is determined by q, which is a function of time, t, such that:

$$\frac{\partial q}{\partial t} < 0$$

A person loses quality of life of δ should they become ill but this if offset by treatment, represented by $w_{(p)}$

$$Quality\ of\ Life = q_{(t)} - r\partial + rw_{(p)}$$

This is divided by q to be between 0 and 1, with 1 (when r=0) representing a full quality of life as $w_{(P)} < \delta$.

$$0 < \frac{q_{(t)} - r\partial + rw_{(p)}}{q_{(t)}} < 1$$

A cubic function is used to represent the path of a person over the course of their life. After filling in the relevant variables, this gives the final integral to be maximised, subject to the same budget constraint as before:

$$(P, C) = \int_0^{L+\,rT_{(P)}-r\lambda} (Log(C)(\frac{(1-r)q_{(t)} + rw_{(p)} - \partial r}{q_{(t)}})^3 - [L+ rT_{(P)} - r\lambda]$$

Subject to C + P = M