The Demand for Medical Care

We will now describe how an individual's preferences determine her demand for medical care/health services or health products. In the previous classes we have characterized an individual's taste for her own health or physical wellbeing as a durable good, and the demand for health services and products is a derived demand as a result of our demand for our own wellbeing.

To be precise, let's characterize all the "goods" that is consumed by a typical consumer be X which is a composite vector of goods. By that I mean think of X as a whole spectrum of goods that has nothing to do with medical services and products, but definitively contribute to your quality of life such as a house, refrigerator etc. And let H be our own health. Together, they capture everything this individual desires.

We had argued earlier that we can then characterize an individual's preferences as $U(X,H)$. We want this utility function to be increasing and concave in goods (this means that the first order derivative should be non-negative, and the second order should be non-positive.), and health consumption. That is we want it such that as we consume more of each good, our satisfaction from its consumption increases. But of course the marginal increase in satisfaction or utility will fall as we consume more.

The problem in leaving the formulation at this is that health per se is not for sale, but medical services and products (m) are. We had characterized this as a production function of medical services and products (for the moment, abstract from concerns due to lifestyle and such), $H = h(m)$, where our health is increasing in our consumption of medical services, but however like inputs into a production process, it suffers from diminishing marginal productivity (concavity). Let the price of medical services and products be p_m and that of all other goods as p_x. Then the budget constraint of the individual is just $y = p_m m + p_x X$, where y is just the income of the individual.

Another way to think of the budget constraint, if we were to plot it in terms of H and X, then it is the individual's production possibility frontier given the technology for her health, and her budget. But how should it look like then? Note the following;

$$H = h(m) = h\left(\frac{y - p_x X}{p_m}\right)$$

$$\Rightarrow H_X = \frac{\partial H}{\partial X} = \frac{\partial h}{\partial m}\frac{p_x}{p_m} = -h_m \frac{p_x}{p_m} \leq 0$$

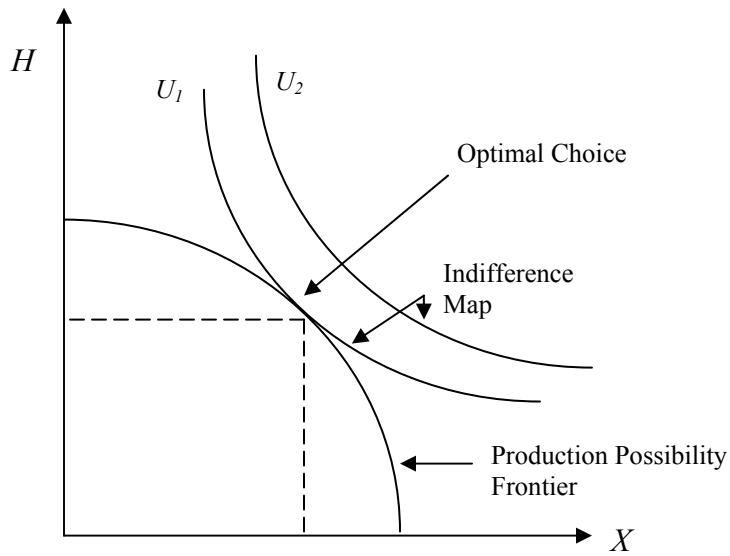
$$\Rightarrow H_{XX} = \frac{\partial^2 H}{\partial X^2} = h_{mm}\frac{p_x}{p_m} \leq 0$$

As for the individual's indifference curve,

$$dU = dX\frac{\partial U}{\partial X} + dH\frac{\partial U}{\partial h} = (dX)U_X + (dH)U_H = 0 \Rightarrow \frac{dH}{dX} = -\frac{U_X}{U_H} \leq 0$$

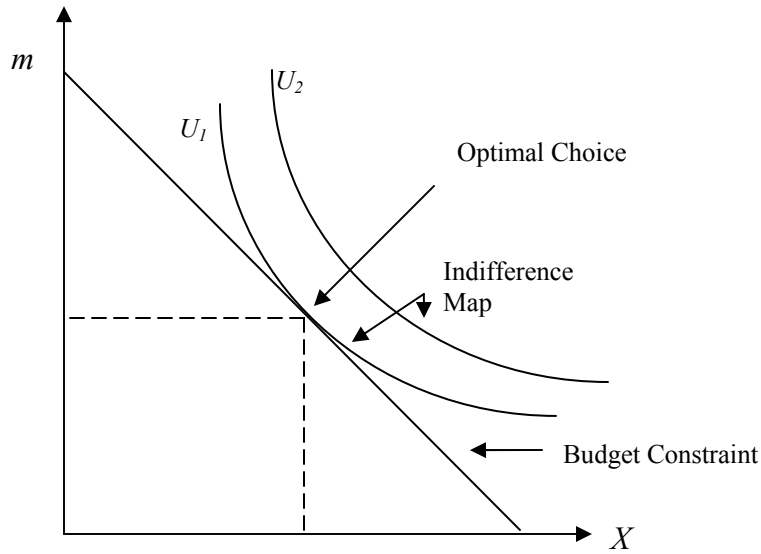
$$\frac{d^2H}{dX^2} = -\frac{U_{XX}U_H - U_{HX}U_X}{(U_H)^2} \geq 0$$

Which means that the indifference curve in a diagram with H on the ordinate, and X on the abscissa will be downward sloping, and be convex. So it will look like this,



In this form, what the diagram is saying is that our health production possibility set, or the set of choices that are available to the individual is determined partly by the medical technology that is available to the individual, given her income. If this individual want to maximize her wellbeing, then given the possibility frontier, the rational individual will choose a point on the boundary of the frontier where it here wellbeing is the highest given the way she ranks her preferences as depicted by the map of her indifference curves.

And in terms of your typical constrained maximization problem, where you have "goods" consumer on both the abscissa and the ordinate,



The solution to the problem can then be characterized as follows,

$$\max_m U\left(\frac{y - p_m m}{p_X}, h(m)\right)$$

$$\Rightarrow U_X \frac{\partial X}{\partial m} + U_h \frac{\partial h(m)}{\partial m} = -U_X \frac{p_m}{p_X} + U_h h_m = 0$$

$$\Rightarrow U_X \frac{p_m}{p_X} = U_h h_m \Rightarrow \frac{U_h h_m}{U_X} = \frac{p_m}{p_X}$$

Where the equilibrium condition is your usual equating of the marginal of substitution between the consumption of two goods, here medical services and products against all other goods, and their price ratio, $MRS = \frac{U_h h_m}{U_X} = \frac{p_m}{p_X}$. In this diagram, it shows that her choice of the amount of medical services and products that she consumes with all other goods, is limited by her budget. Assuming she does not save in any period of her life, she then maximize her wellbeing by consuming these two goods by completely expending her entire allocated budget, such that her indifference curve is just tangent to the budget constraint. **Can you show that the equilibrium conditions are the same in both diagrams after some rearrangements of the equation?**

This equilibrium condition in effect gives us the demand for medical care and services for the individual in question. If we were to add all individuals' demand, we would then get the market demand for health services and products.

Some Comparative Statics

1. The Impact of Illness on an Individual

With the above setup, we can now examine how some changes to her behavior or health (say because of an illness) might affect this individual's choice of consumption bundle for X and m. Before we do so, let the relationship between health and medical goods and services be a little more detailed. Let l be illness or factors that negatively affect an individual's wellbeing negatively, while e be all activities that positively affect her health, such that $H = h(m,e,l)$. You can think of our earlier analysis is being derived by treating these factors as being constant. Now what we wish to do is to examine how the individual's choice would be altered as a result of a change in l and e. To add some spice, suppose l stands for illnesses, while e stands for number of hours spent in a gym working out.

We know from before that in equilibrium, the condition for maximized wellbeing is $\frac{U_h(X,h(m,e,l))h_m(m,e,l)}{U_X(X,h(m,e,l))} = \frac{p_m}{p_X}$. Suppose the individual falls ill, then her health status falls, i.e. l increases. Intuitively, we would expect her demand or consumption of health services to increase at the expense of the consumption in all other goods. Let's examine if our intuition is correct. If so, then it would guide us in depicting the shift in the indifference curve.

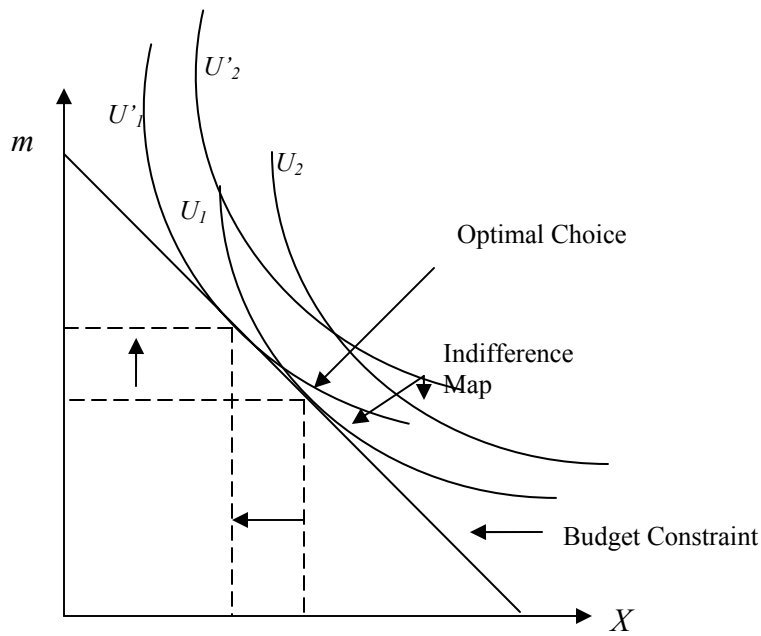
$$\left\{U_{hh}\left(h_l + h_m \frac{\partial m}{\partial l}\right)h_m + U_h\left(h_{mm}\frac{\partial m}{\partial l} + h_{ml}\right) + U_{hX}\frac{\partial X}{\partial m}\frac{\partial m}{\partial l}\right\}$$

$$= \frac{p_m}{p_X}\left\{U_{XX}\frac{\partial X}{\partial m}\frac{\partial m}{\partial l} + U_{Xh}\left(h_l + h_m\frac{\partial m}{\partial l}\right)\right\}$$

$$\Rightarrow \frac{\partial m}{\partial l} = \frac{U_{hh}h_l h_m + U_h h_{ml} - U_{Xh}h_l}{\frac{p_m}{p_X}\left(-U_{XX}\frac{p_m}{p_X} + U_{Xh}h_m\right) - U_{hh}(h_m)^2 - U_h h_{mm} + U_{hX}\frac{p_m}{p_X}} \geq 0$$

Which gives us the correct sign, and it says, as illness intensity increases, the equilibrium medical expenditure would have to increase, given her production function for health where as illness increases, consumption medical services would to increase (i.e. rather perversely, medical services and illness are "complements"), and that our health in the production function of health is falling in illness incidence.

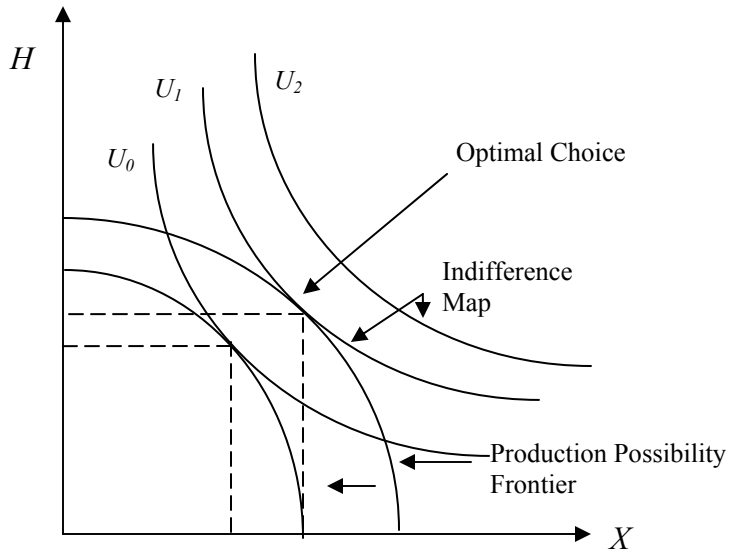
Since we know from our budget constraint that given a budget y, and a set of prices (holding them constant), an increase in m expenditures, must necessarily imply a fall in consumption of X. Diagrammatically, we can depict this as follows:



Further, if the illness has an income effect in a sense that it reduces the individuals labor supply, such as when we model income, $y \equiv y(l)$, as being dependent on illness, or even health status, in which case $y \equiv y(h(m,e,l))$. This would imply a parallel shift downward towards the origin since the set of goods available to the individual has fallen, assuming that the relative price of medication and treatment, and all other goods stay the same (which is not a strong assumption given that an illness should not typically have a market wide effect on demand of all other goods, and treatment, or does it?).

Some questions for you to ponder over:
Is there a change in the curvature of the utility function or indifference curve given the illness event? Can you show it?
Why is there intersection in the indifference curve in this diagram?

We can similarly translate this into the production possibility frontier and indifference diagram depicted below,

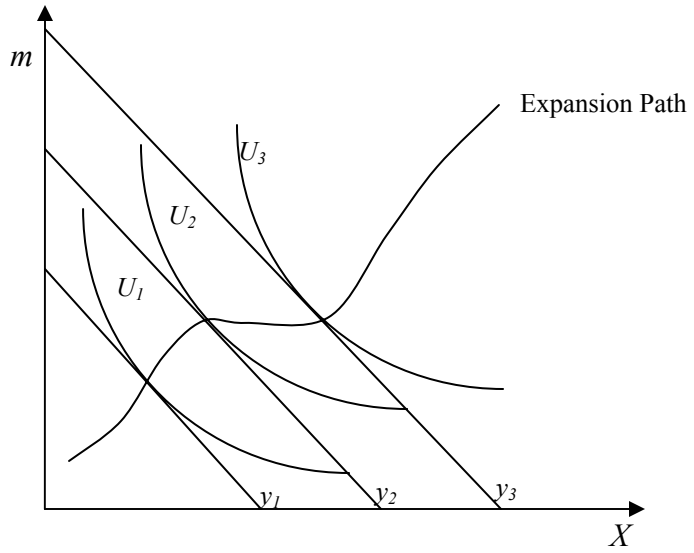


There is shrinkage in the production possibility frontier since the illness event has reduced the amount of personal health available to the individual for enjoyment, and since part of the income resource goes towards consuming medication, so does the consumption of all other goods.

Given the general structure of the model, can you show that this comparative statics, i.e. the impact of the illness event on health gives the following relationship, where illness leads to a fall in consumption of health?

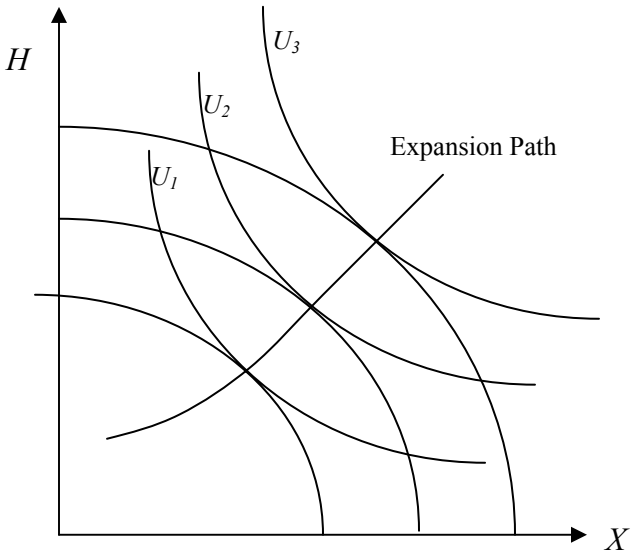
2. The Impact of a Fall in Income on Health

We all know that as income increases, the quality and standard of you life increase. You could afford gym membership, and consequently enhance your health. It also allows you to consume better food that could enhance your health, even if it means taking less vacation etc. So holding all else constant, as your income increases, it implies a increase in your budget set, and consequently allows you to consume more of both goods and services that enhances your health, and more of all other goods. This translates to the following diagram.



Where as your income increases, you attain higher levels of utility, and this is consequently reflected as higher intersections between you budget line and your indifference curve.

Similarly, as your income increases, it also implies that your production possibility frontier expands. We can then similarly draw an expansion path, where each production possibility frontier corresponds with a different level of personal income.



We then draw a more direct relationship between health consumption and medical care consumption as income varies, thereby deriving the Engel curve for health and medical goods and services using the information captured above.

First let us think about the degree of health of individuals who are poor. If they live in the ghetto or slumps of the inner city, it is likely that their health would be poorer compared with someone living in the suburbs. This could be a result of poor sanitation, which could be a result of public neglect of their predicament, or purely their own choice due perhaps to their poverty. If we believe there are no other distinguishing features between individuals besides their own income, then as they progress say through to higher income brackets, we would see and increase in their health due to better food, access to good sanitation, better lifestyles that are available to them.

If that is the be all and end all, then the Engel curve would just be a upward sloping straight line due purely to pure Income Effect, as exemplified by the parallel shifts in the budget constraint and equal shifts in the production possibility frontier outwards. However, we have also notice that the rich have access to better health insurance plans, and lifestyles, which consequently suggests that at some income threshold, the rate of increase in health may be faster, that is the line may be an upward sloping convex curve. At the same time, however, the increased levels of stress may outweigh the better access to this better lifestyle, creating a downward sloping segment. This Engel curve would be just as depicted in your text, page 106.

Deriving the Individual's Demand Curve from Utility Maximization

We know the equilibrium condition is described by the following condition, $MRS = \frac{U_h h_m}{U_X} = \frac{p_m}{p_X}$, which says that in equilibrium an individual should optimally consume medical services and all other goods in her basket up to the point where their marginal rate of substitution equates with their price ratio. This then implicitly defines for us the individual's demand.

We will be a little more precise now, and assume a functional form for the individual's utility function, or the measure of her wellbeing from consuming the goods of her choice. Let the utility function be $U(X, h(m)) = X^{\alpha} m^{\beta}$. All other variables such as income and prices remain the same in notation. Then demand for medical services using the equilibrium condition above is

$$MRS = \frac{U_h h_m}{U_X} = \frac{\beta X^{\alpha} m^{\beta-1}}{\alpha X^{\alpha-1} m^{\beta}} = \frac{\beta X}{\alpha m} = \frac{\beta\left(\frac{y - p_m m}{p_x}\right)}{\alpha m} = \frac{p_m}{p_X}$$

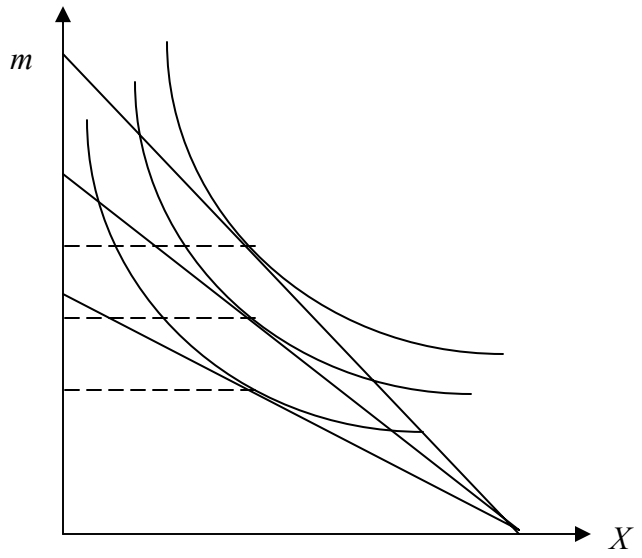
$$\Rightarrow \beta(y - p_m m) = \alpha m p_m$$

$$\Rightarrow m^* = \frac{\beta y}{(\alpha + \beta) p_m}$$

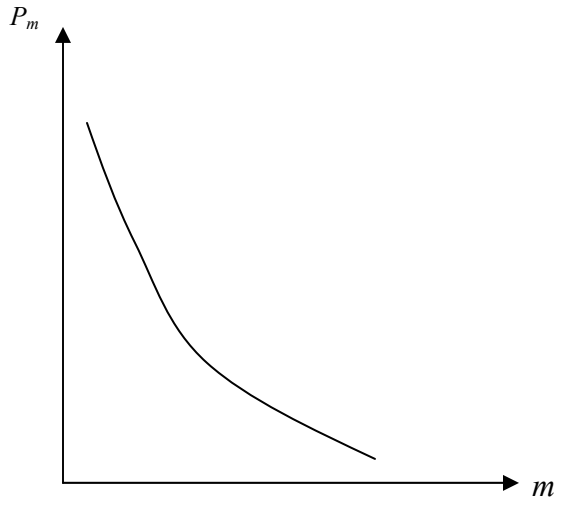
$$\Rightarrow \ln m^* = \ln \frac{\beta y}{(\alpha + \beta) p_m} = [\ln \beta - \ln(\alpha + \beta)] + \ln y - \ln p_m$$

$$\Rightarrow M = K + Y - P_m$$

In this latter form, we can then depict the individual's demand equation as a typical straight line holding log income constant. It tell us that given this structure, that a 1% increase in price leads to a 1% decrease in medical expenditure. We will examine the relationship between the indifference curve depiction and that of the individual's demand for medical services.



As the price of medical services and products falls, like any good, we can think of it as increasing your demand (Though I do not foresee that I may choose to increase the frequency of my visits to my dentist even if she reduces her rates!). Such as increased consumption of preventive medication, and skin care products etc.. Each upward shift in the budget constraint pivots on the ordinate since we have held the price of all other goods constant. Each price level of medical services and products then corresponds to a point on her demand curve, and we obtain the standard demand curve.



And as usual, if her income increases, then it implies a shift in the demand curve since each demand is depicts specific to a level of income. Also to obtain the market demand

for the medical service and product, all we need to do is to add the quantity demanded at every given price to find it; that is to horizontally sum the demand (**not the inverse demand!**).

Impact of Illness on Demand for Health

As we have noted before, the technology available to us in the production of health depends on other factors as well, such as lifestyle, illness, etc. All of which would affect our enjoyment of our health, *H*. We have found that the individual would consume more of medical services and products, at the expense of all other goods when an illness befalls them. **This suggests then that when we draw our demand curve, which is for a particular level of health status, that an illness event would raise an individuals demand for medical services at each and every price level. This then translates to a higher level of demand.**

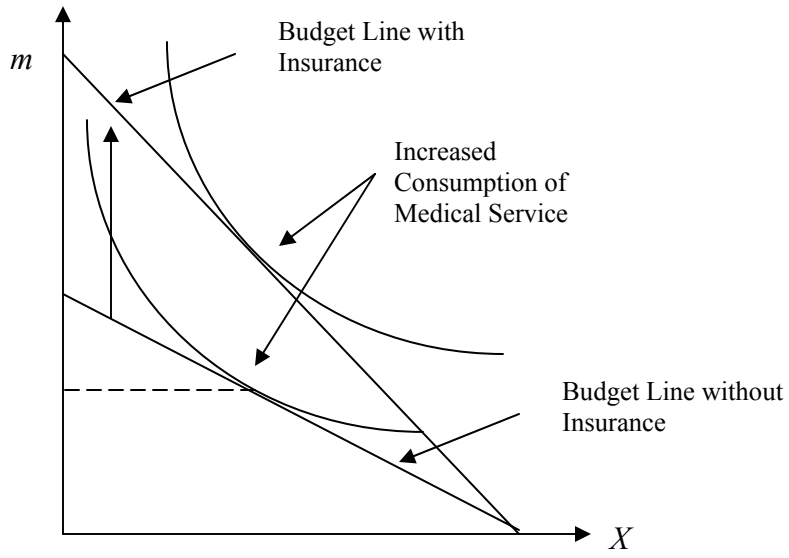
Over-Simplification of Model?

Of course what we have done so far has barely grazed the true complexity of individual choice when health decisions are made. Consider the following; when an individual contracts a disease, there are likely several treatments available, the choice of which would be dependent on the degree to which the two treatments are complements or substitutes, consequently their relative price and perceived effectiveness in treatment would affect the choice of usage. So that if relative prices between two or more treatments change, then so would the demand for the treatments.

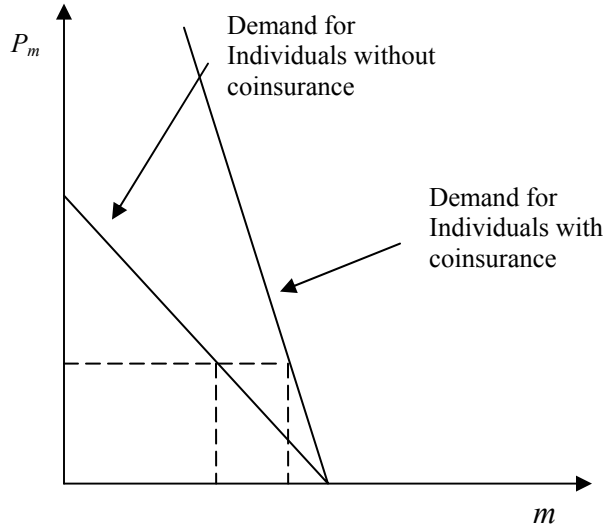
Effect of Health Insurance on Individual Choice of and Demand for Health Care

We have discussed briefly how health insurance might affect demand. But how does it enter into a model of our utility maximization model? We will examine this here now first by listing possible factors that could affect individual choices.

1. **Copayments**: Defined as a sharing arrangement or rule between the consumer and the insurance firm as specified in the insurance contract. The most common forms of which are:
    a. **Proportional Coinsurance Rate**: This leads to a change in the slope of the budget constraint since the actual quantum provided to the consumer is dependent on the level of health care purchased. To see the effect of such a copayment, consider the individual first with health insurance, then with health insurance with a Proportional Coinsurance Rate.



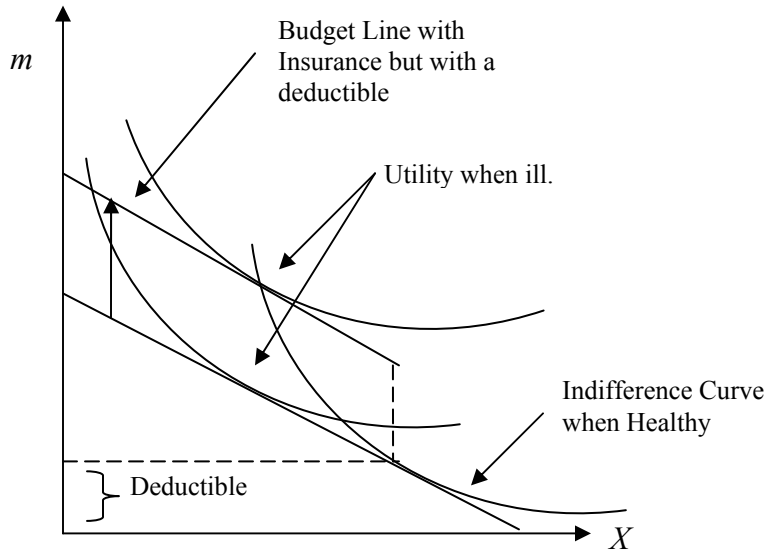
We can then translate this to individual and on the aggregate market demand. One for those who are insured, and those who are not; For those who are insured, compared to their none insured counterparts, at every **positive** price, because of this copayment scheme, their would be higher. Note that when price is zero, there is no difference in demand between those who are insured, and those who are not.



Can you prove to yourself using the framework used in our model that this should what happens to the demand curve?

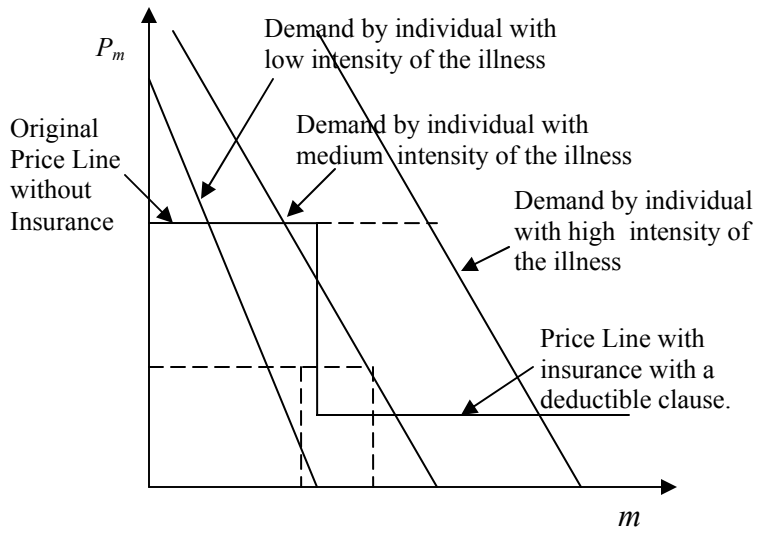
b. **Flat Indemnity Payment** by the Insurance Firm: This leads to a parallel shift in the budget constraint since it simply adds to the available income of the individual when the illness occurs, that is it is a pure income effect. We can use a similar analysis as what had done above. **Can you do the same first using the utility maximization model, and then the demand curve? How would the two types of demand, one for insured, and another for non-insured individuals differ? Why?**

2. **Deductibles**: Defined as the minimum amount the consumer has to pay before the insurance firm would process a claim, and make the payout. The purpose is so as not to be involved with small claims that would increase the administrative cost of the insurance. For ease of illustration,



What the diagram above says is that when the individual is well, it makes no difference whether he has insurance or otherwise, since his consumption of medical care is below the deductible. However, should the intensity of his illness rise, causing the shift in his health status such that the cost of treatment is above the deductible amount, without an insurance contract, only a lower level of medical is available to him, while if he had obtained insurance, he would enjoy a higher level of medical care.

To see the effect of a deductible in terms of a demand diagram, consider three different individuals each with a particular illness but with different intensities. Let's further assume that the supply of the medical treatment is the same, with the exception of quantity that the patient/consumer can purchase.



Then what happens is that the insurance contract with a price line has a kink such that below a particular level of quantity of medical care consumed, the price stays the same for an with a low intensity in the illness individual regardless of whether he is insured or otherwise due to the deductible. However, as the intensity increases, the different levels of medical care demanded starts differing, whether an individual has insurance or otherwise, since once the insurance kicks in, the individual could enjoy a higher level of medical care due to lower effective price.

3. **Maximum Payment Limits**: Defined as the payout limit beyond which an insurance firm would not make anymore payments. This limit may be for each year, or an entire lifetime. What this says is that the Insurance firm will not insure serious events.

A typical insurance plan in fact incorporates all or a combination of some of this facets into an insurance policy.

Suppose an individual has a health insurance contract that offers a flat indemnity payment, but also has a deductible, and a maximum liability as described above. How would the individual budget line change?

Estimating the Demand for Health/Medical Care

There are other considerations that we might have neglected in abstracting from reality that may be useful in our model. Some of them are the following;

1. Opportunity cost from labor supply,
2. Travel cost to treatment center,
3. Waiting time for treatment,
4. Quality of medical care, and medical product, and
5. Beliefs of patients

These factors although not modeled explicitly can aptly be captured by any factors we enter in the production function of individual health, *H*, depending on whether they have a negative or positive effect on health as we have discussed earlier during our introduction. However, when we take our analytical model to the data, we have to bring all of these concerns into our empirical analysis which we will study next.

When including the time cost for an individual we can use labor income as a proxy, and/or the individual's labor supply. Travel cost can be measured directly as well using standard geographical measures, using a straight line distance perhaps as a proxy multiplied by the fuel cost. We could also use the average waiting time of differing intensity illness as indicators of waiting time to find the impact it has on demand for any particular form of medical care. We could proxy quality by the survival rate, or recovery rate for quality of medical care. However, beliefs of a patient is an unobservable which will affect our results, and we must always be cognizant of the impact individual beliefs might have on demand.

Our previous analysis had derived a particular individual's demand for medical care. However, given the functional form, we have price and income producing unit impact on the individual's demand for medical care. This may be verified. Typically, when economist studies a phenomenon, we apply simple model first, and it is usually an additive model.

In the simplest instance, we can use our analysis to describe an individual's demand for medical care as $m = M(y, p, l)$. When applying the model to data, an additive model would imply that we perform a regression of the following;

$$m = M(y, p, l) = \beta_0 + \beta_1 p + \beta_2 y + \beta_3 l$$

where $\beta_0, \beta_1, \beta_2, \beta_3$ are just coefficients, and essentially measuring the partial effect of income (*y*), price (*p*), and illness (*l*) respectively, and where the first constant is just the minimal amount of medical care that is always demanded. By partial effect, I mean the effect of demand for the quantity of medical care for a unit change in the variable. Consider price, and suppose that β_1 has a value of -0.2. Then a $1 increase in price would lead to a 0.2 unit fall in quantity demanded of the medical care service or product. Our analysis would inform us that although the magnitude of the impact may not be what we expect, but assuredly the sign cannot or should not. So we would expect the coefficient for *p* to be negative, positive for *y* and *l*. However, when performing empirical

analysis, we are concerned with both sign of the coefficient, their magnitude, and their statistical significance (in other words the degree of confidence we have in the revealed magnitude of impact.) When we perform a regression analysis, we are using information drawn from all consumers. The estimated coefficient which is what we are interested in is common to all, that is what we are saying is that although each individual may have distinct differences and preferences, the effect of prices on their demand for medical care common to all.

In this form, we have effectively negated the impact of health insurance. Suppose what every consumer purchases is a insurance contract that offers a flat insurance indemnity of *Y*, with a premium of *R*. We would then have to augment the empirical model by changing the income measure, that is

$$m = \beta_0 + \beta_1(p - Y) + \beta_2(y - R) + \beta_3 l$$

where *Y* reduces the actual price of medical care, and *R* reduces the individual's available income in any period.

However, if we really think about it, few medical treatments and service are ever used in isolation, for example a doctor is assisted by a nurse, diagnostic specialists, etc. all of which would affect the individual's demand, and to ignore their impact would bias the results we obtain. Suppose the medical care we have been considering, *m*, is for physician services. Let *d* be the price of diagnostic services. Then a better model would be

$$m = \beta_0 + \beta_1(p - Y) + \beta_2(y - R) + \beta_3 l + \beta_4(d - R_d)$$

where R_d is the insurance indemnity sum for diagnostic services. We could and should keep the process going so as to ensure we capture all pertinent aspects that affect an individual consumer's demand for the particular medical care. The sign of the coefficient to the cost of diagnostic services should be positive as well. However, if we had considered a substitute treatment instead, then we would expect the price of the treatment for this substitute to be negative.

We will next examine some empirical studies on demand.