

A Behavior Model of Physicians

Within the Framework of Leisure

versus

Output Theory of Labor Supply

Kong-Kyun Ro

John A. Powers*

I. Introduction

What is the supply function of physicians' services in the United States? Recent studies indicate that physicians generally operate on the backward bending portion of a supply curve.¹⁾ This has a serious policy implication, for any measure which increases the demand for physicians' services and, thereby the price, will worsen the physician shortage, however defined.²⁾ The purpose of this paper is to build a behavior model of physicians, which will integrate the triple role of the physician as provider of medical care, entrepreneur-manager, and consumer. For analytical convenience, we will confine our study to physicians in solo, fee-for-service practice.³⁾

* Authors are both Associate Professors of Economics at the University of Cincinnati. Professor Ro holds a Ph.D. from Yale University and Professor Powers from Purdue University. We would like to thank Richard D. Auster and Morris Silver for making their mimeographed paper, "Leisure vs. Output: A Revision of the Theory of Supply" available to us. Richard Auster sent us another mimeographed paper entitled, "The Supply of Dental Services", June, 1970. We found the above two papers extremely helpful to us. We would like, also, to thank Bruce E. Balfe for his comments.

1) Martin S. Felstein, "The Rising Price of Physicians' Services," *Review of Economics and Statistics*, Vol. 52 (May 1970) pp. 121-133. See p. 132; and Uwe E. Reinhardt, *An Economic Analysis of Physicians' Practices*. Unpublished Ph.D. dissertation, Yale University, 1970. See p. 78.

2) We are assuming that the demand curve cuts the supply curve from under, e.g., the stability condition.

3) According to the 1969 AMA study of 3,937 physicians, 57 percent of all active M.D.'s belongs to this category.

A backward-bending curve of labour supply implies that leisure is a superior good and that income effect outweighs substitution effect. Such a curve is a reflection of the behavior of a worker who acts as a consumer attempting to maximize utility by choosing the optimum division of his time between work and leisure. This well-accepted assumption of consumer behavior would also be applicable to an individual supply curve of physicians' services, if the physician were providing medical care on a salary basis. The typical American physician, however, operates as the owner-manager of a solo proprietorship, where he renders productive services to his own firm. Herein lies our problem. If a physician *is* a firm, is the utility maximization behavior of the physician as consumer inconsistent with the profit maximization behavior of the physician as entrepreneur?⁴⁾ If so, how does this conflict affect the supply response of physicians' services? Our behavior model of physicians indicates that there is no conflict because a physician's entrepreneurial function can be separated conceptually from his function as the provider of labour-input for "physicians' services."

Section II presents the model, and Section III the necessary and sufficient conditions for a backward-bending supply curve of physicians' services.

II. Behavior model of physicians

A physician is seen behaving so as to maximize his utility (U)

$$U = U(Y, B) \quad (1)$$

where Y = net income.

B = leisure.

The production function of physicians' services can be expressed as:

$$Q = AL_P^\alpha L_A^\beta K^\gamma, \alpha + \beta + \gamma = 1 \quad (2)$$

where Q = output.

L_P = labor input of a physician.

L_A = labor input of ancillary personnel.

K = a vector of other inputs such as facility and medical supplies.

Note that L_P and L_A are treated as separable in the sense of Leontief. For the sake of convenience, we assume that entrepreneurial decisions by a physician are made simultaneously with decisions of the amount of L_P and

4) According to J. de V. Graaff, it is possible to have a backward-bending supply curve of a firm because entrepreneurs maximize utility rather than money profit. See J. de V. Graaff, "Income and the Theory of the Firms," *The Review of Economic Studies*, Vol. 18, No. 45 (1950-51), pp. 79-86.

that entrepreneurship does not take any time. This enables us to consider that a physician's total time consists of his leisure time and the time spent providing L_P . Thus we have:

$$L_P \equiv \bar{T} - B \quad (3)$$

where \bar{T} is a physician's total time.

The net income Y is defined as follows:

$$Y = (1-t)(pQ - wL_A - rK) \quad (4)$$

where t is tax rate, p the price of physicians' services, w the average wage rate of ancillary personnel and r the average rent or price of other inputs. Assuming that a physician has neither monopoly nor monopsony power, p , w , and r are considered to be constant. The tax rate is also assumed to remain the same. Since these constants are exogenous variables, if we exclude equation (3) on the account of its being an identity equation, we have three unknowns (L_P , L_A and K) and three equation, thus making the model complete.

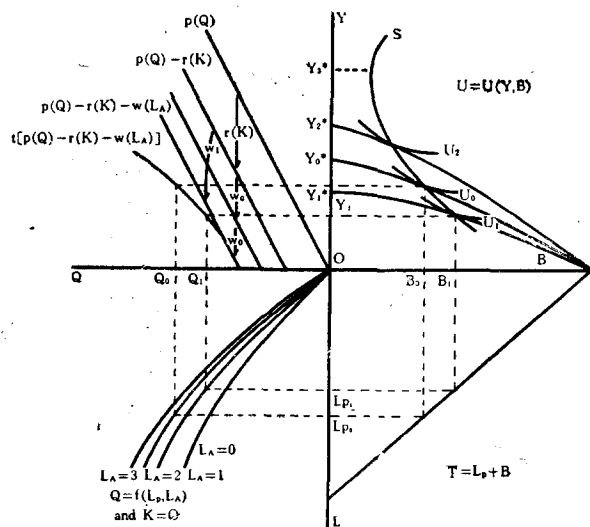
Note that decisions by a physician as a consumer, a provider of labour input and an entrepreneur-manager are interdependent with each other. The decision as a consumer to maximize utility depends on the cost of leisure. The cost of leisure is determined by the net income, which is in turn determined by the number of hours a physician decides to work, L_P , and the production function, given p , r , w and t .

A diagrammatic exposition will clarify our model. In the N.E. quadrant of Figure 1, various income and leisure opportunity frontiers are given, where each frontier (curve) shows the rate at which leisure can be transformed into net income. Suppose a physician faces an income-leisure opportunity curve Y_0^*B . In order to reach the highest indifference curve possible, he chooses the amount of leisure OB_0 . This means that physician's labour input is OL_{P_0} , because all non-leisure time is supposed to be devoted to producing physicians' services (see the S.E. quadrant). Given this physician input, the production function as shown in the S.W. quadrant determines the various levels of output obtainable according to the number of aides to be employed. The amount of capital is assumed to be held constant for our short-run analysis. For the physician input of OL_{P_0} , the wage rate is such that rational choice indicates employing two aides, i.e., the marginal revenue product of the second aide equals the going wage rate. With two aides and capital K , output OQ_0 is transformed into net income OY_0 according to p , r , w , and t as shown in the N.W. quadrant. Note that an assumption is made that

physicians are price takers and, therefore, $p(Q)$ is a linear function. It is further assumed that $r(K)$ is also linear. Thus, line $p(Q)$ is lowered in parallel by the amount of $r(K)$. The third and fourth lines are drawn by lowering line $(p(Q) - r(K))$ in parallel by the amount to be paid to the first and second aide respectively. The vertical distance between the third and fourth lines is equal to that between the second and third lines because physicians are assumed to have no monopsony power. As for the "tax curve", it is bent downward as output increases to indicate that a progressive income tax rate is applied⁵⁾.

The effects of changes in p, r, w , and/or t can be analyzed with Figure 1. Suppose the wage rate of aides went up by 100%, i.e., $\Delta w = w_0$. This presents to our physician an income-leisure opportunity locus of Y_1^*B , which is naturally lower than Y_0^*B . Since the price of his leisure is lower now, the physician takes more leisure by trading work for leisure by the amount of $L_{p0}L_{p1}$ or A_0B_1 . With the smaller physician input of OL_{p1} , the marginal product of an aide is smaller. At the same time, the wage rate is now assumed to be higher. Therefore the physician employs one aide only and produces smaller output OQ_1 . Since the increase in wage rate makes $2w_0(L_A) = 1w_1(L_A)$, we can use the N.W. quadrant as it is to arrive at OY_1 . The

Figure 1



5) Progressive tax rate is to be applied to physicians. However, for convenience, in algebraic analysis, a proportional tax is assumed previously in this paper.

effects of changes in r or p can be analyzed in a similar way. Since one of our primary interests is to find out whether $\frac{\partial Q}{\partial p} > 0$ or $\frac{\partial Q}{\partial p} < 0$, the effects of changes in p will be analyzed more rigorously in the following.

III. The Shape of the Supply Curve of Physicians Services

According to Figure 1, the supply curve of physicians' services can be obtained by joining the points of tangency between indifference curves and income-leisure opportunity curves in the N.E. quadrant. It differs from the traditional supply curve of labor in that the horizontal axis shows leisure time instead of working hours and the vertical axis represents the net income of a firm rather than wage rate. The leisure time can easily be translated into working hours by flipping the curve over because $\bar{T} = L_p + B$. Thus, for the incomes above Y_3^* , the supply curve of L_p is backward-bending.

The crucial difference from the usual supply curve of labour is that the net income of a firm, Y , cannot automatically be translated into the price of labor. We need to know the production function, factor prices, the price of output and tax rate. Thus, even if the level of physicians' incomes and their preferences are such that income effect outweighs substitution effect in their leisure-work choices, an increase in p does not lead to a decrease in Q so long as there is a sufficient proportionate in L_A and/or K . This obvious point has often been overlooked because the entrepreneur-managerial role of physicians is often neglected and because of the tendency to equate physicians' services Q with their labor input L_p . In the following, we present a proof of this *a priori* reasoning.

Given the production function (2) and income constraint (4), we have

$$\frac{\partial Y}{\partial L_A} = (1-t) \left[p \frac{\partial Q}{\partial L_A} - w \right] \quad (5:1)$$

and

$$\frac{\partial Y}{\partial K} = (1-t) \left[p \frac{\partial Q}{\partial K} - r \right] \quad (5:2)$$

If we set equations (5:1) and (5:2) to zero to indicate the profit maximizing behavior of a firm in hiring the factors of production, we get the following necessary and sufficient conditions for the income frontier (e.g., income-leisure opportunity curve).

$$p\beta AL_p^\alpha (L_A^*)^{\beta-1} (K^*)^{\gamma-1} r - w = 0 \quad (6:1)$$

$$p\gamma AL_p^\alpha (L_A^*)^\beta (K^*)^{\gamma-2} r - r = 0 \quad (6:2)$$

Solving (4) for L_A^* and K^* :

$$L_A^* = \left[\frac{pA\gamma^r w^{r-1}}{\beta^{r-1} r^r} \right]^{\frac{1}{\alpha}} L_p \quad (7)$$

$$K^* = \left[\frac{pA\beta^{\beta} r^{\beta-1}}{\gamma^{\beta-1} w^{\beta}} \right]^{\frac{1}{\alpha}} L_p \quad (8)$$

$$\frac{L_A^*}{K^*} = \frac{\beta r}{r w} \quad (9)$$

Substituting (7) and (8) into (4) :

$$Y^* = (1-t) \alpha \left[\frac{pA\beta^{\beta} \gamma^r}{w^{\beta} r^r} \right]^{\frac{1}{\alpha}} (T-B) \quad (4A)$$

Substituting (7) and (9) into (2) :

$$Q^* = \left[\frac{Ap^{1-\alpha} \gamma^r \beta^{\beta}}{w^{\beta} r^r} \right]^{\frac{1}{\alpha}} L_p - \frac{W}{p\beta} L_A^* - \frac{rK^*}{p\tau} \quad (2A)$$

Assuming $dw=dr=dt=0$ as before, from (2A) we get :

$$dQ^* = \frac{W}{p\beta} \left[dL_A^* - L_A^* \frac{dp}{p} \right] \quad (10)$$

From (7), (8), and (9) :

$$\frac{dL_A^*}{L_A^*} = \frac{dK^*}{K^*} = \frac{1}{\alpha} \frac{dp}{p} + \frac{dL_p}{L_p} \quad (11)$$

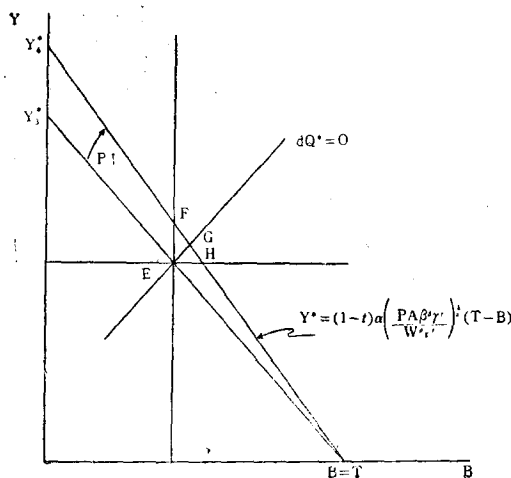
Now we have our necessary and sufficient conditions :

$$dQ^* \geq 0, \text{ iff } \frac{dL_p}{L_p} \geq \frac{\alpha-1}{\alpha} \frac{dp}{p} \quad (12)$$

or

$$dQ^* \geq 0, \text{ iff } \frac{dL_A^*}{L_A^*} = \frac{dK^*}{K^*} \geq \frac{dp}{p} \quad (13)$$

Figure 2



Thus, to reiterate our previous statement, an increase in output price would lead to a decrease in output, if and only if L_p decreases and the proportionate increase in L_A and K are not large enough to offset it.

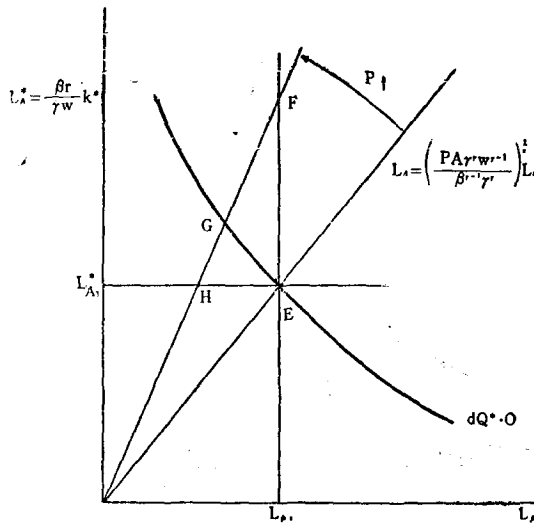
This point can further be clarified by a geometrical exposition. Assuming Y is a negative linear function of B , i.e.,

$$\frac{\partial Y^*}{\partial B} < 0 \text{ and } \frac{Y^* \partial^2}{\partial B^2} = 0,$$

we can redraw the N.E. quadrant of Figure 1 as shown in Figure 2. (See equation (4A)). The only addition is $dQ=0$ line which is drawn on the assumption of homogeneous of degree one for or production function (2).

Suppose an increase in output price rotates income frontier $Y_3^* B$ to $Y_4^* B$. If a physician's indifference curve touches $Y_4^* B$ line on the left of F , then there is an increase in output and L_p but an increase in Q . When and only when the point of tangency is between G and H , there are decreases both in L_p and Q .

Figure 3



Since the possibility of an increase in output in spite of a decrease in L_p arises because of a greater proportionate increase in L_A and/or K , the process of adjustment in input-mix in response to a change in output price is examined in Figure 3.

If we let X and Y axes represent L_p and L_A respectively, the $dQ=0$ curve is now the familiar isoquant curve and the lines drawn from the origin

represent expansion paths. (Although we have three inputs, a two dimensional diagram is used because $L^* \equiv \frac{\beta \gamma K^*}{\gamma w}$ (equation (9)), For L_A^*/L_p , see equation (7)).

If the adjustment made in input-mix to the increase in output price is such that the new equilibrium position lies between G and F , then we have the case of an increase in A in spite of a decrease in L_p . When and only when the new equilibrium position lies between G and H , then $\frac{\partial Q}{\partial p} < 0$.

The above result has an interesting policy implication. Given the current institutional and legal barriers to the supply response of MD's as well as the time lag involved to the expected increases in output price, keeping the wage rates of ancillary personnel stable by making their supply response sensitive appears to be essential.