

# Physician response to fee changes with multiple payers\*

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This paper develops a general model of physician behavior with demand inducement encompassing the two benchmark cases of profit maximization and target-income behavior. It is shown that when income effects are absent, physicians maximize profits, and when income effects are very strong, physicians seek a target income. The model is used to derive own and cross-price expressions for the response of physicians to fee changes in the realistic context of more than one payer under the alternative behavior assumptions of profit maximization and target income behavior. The implications for public and private fee policy, and empirical research on physician response to fees, are discussed.

## 1. Introduction

In 1992, Medicare, the largest payer for health care in the U.S., will begin the transition to paying physicians according to a new Medicare Fee Schedule (MFS). The MFS is a procedure-level fee schedule based in part on the work of Hsiao and his colleagues, and includes adjustments for input cost differences across geographic regions.<sup>1</sup> The MFS will introduce substantial changes in prices paid by Medicare. For example, according to Levy et al. (1990) from the Health Care Financing Administration (HCFA), the fee for one of the highest volume Medicare procedures, a cataract removal and lens implant (CPT-4 code 66984), would have been reduced from an average

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<sup>1</sup>See Hsiao et al. (1988) for a description of the methodology used to estimate the relative value of physician own inputs.

of \$1,634 in 1988 to \$1,279 had the MFS been in place. Other fees, such as the fee for a limited office visit (code 90050) would have been raised from an average of \$20 to \$26, a 31 percent increase.

Changes in fees for procedures can add up to profound changes in income for physicians in different specialties and in different locations. Levy et al. calculate (on the basis of budget neutrality and the existing pattern of Medicare claims) that income from Medicare for general practitioners would go up by 34 percent, and go down by 26 percent for thoracic surgeons. Physicians in Manhattan would be paid 27 percent less under the MFS, and physicians in rural Missouri would be paid 40 percent more. However, the federal budget reconciliation will cause physicians on average to receive lower fees from Medicare. HCFA's latest projection (contained in the Notice of Proposed Rule Making of June 5, 1991) predicts a reduction in physician fees of 16 percent when the MFS is fully phased-in by 1996.

It is relatively easy to see how prices would change with a MFS. But what about quantities? One argument for the MFS is that it would offer better incentives with regard to quantity than the old system. To judge whether changed incentives are truly better, one needs some idea of how they will change quantities.

A standard model which treats the physician as a profit-maximizing multiproduct firm subject to no demand constraint at given fees predicts unequivocally that the quantity of services will fall following a fee reduction; physician firms will move back down their supply curves. This view is questioned by some on the grounds that it fails to recognize physicians' supposed tendency to adopt tactics to maintain their income in response to price changes. [Rice and Labelle (1989)]. An alternative model would be based on the view that physicians can 'induce demand' to sustain an appropriate 'target income' in response to a fee fall. At a minimum, an increased quantity demanded will be created in order to replace some of the income lost due to a lower price.<sup>2</sup>

There is considerable controversy over some aspects of the target income idea. It is difficult to explain why physicians would pursue a target income in the first place, difficult to explain how targets are set, and difficult to explain the evident differences in targets across individuals. In addition to these commonly noted problems, current formulations of the model are inadequate for prediction in typical U.S. markets in which physicians supply services to many payers. Simply put, when Medicare reduces fees, Medicare alone may not bear the burden of any extra demand inducement. With Medicare fees lower, a physician may want to induce demand in the other segments of his

<sup>2</sup>HCFA actuaries have incorporated a 50 percent 'volume offset' in the cost projections, in essence, assuming that physicians respond to a fee fall by increasing quantity to Medicare enough to recoup half of revenue losses.

or her practice, especially if fees remain relatively high. A theory of target income with multiple payers must explain the best way to hit the target.

This paper will develop a general model of physician behavior with a subjective inducement cost that encompasses the two benchmark cases mentioned above: the familiar 'literal target income', with the physician driven by powerful income effects to attain a fixed net income at one extreme, and a model with no income effects on inducement (and only substitution effects) at the other extreme. The first variant corresponds to the views many physicians have of their colleagues (and underlies Medicare's 'expenditure cap' policy), while the second is the model envisioned by those who favor the MFS for its incentive properties.

In both versions of the model, the physician is assumed to suffer a utility loss from inducement. It is this 'internal conscience', along with the usual upward-sloping labor supply curve, that determines the volume of services physicians provide in total and to sets of patients.<sup>3</sup> We analyze physician responses to relative fee changes by one payer when the physician supplies services to persons insured by other payers as well.

A number of papers in health economics claim to provide empirical support for the idea of a target income. [Rice and Labelle (1989) provide a survey.] We postpone commenting on this literature until our own model is set out. We can summarize our views, however, as follows. First, while there is perhaps some suggestion of modest income effects in physician supply behavior, there is little support for the extreme form of income effects associated with anything like the literal target income hypothesis. Second, observed supply response to a price change affecting a small part of a physician's practice cannot be used to differentiate the two theories. Third, a test that does distinguish between the two models depends, in a way to be described rigorously below, on the relative size of the income and substitution effects of price changes. One goal of this paper is to clarify the implications of research on physician response to fee changes, especially when multiple payers are involved.

Section 2 introduces our approach to physician behavior in the familiar one-payer/one-price schedule context, demonstrating how maximizing and target behavior fall on the ends of a continuum depending on the strength of income effects on inducement behavior. By assuming income effects are extremely strong, we reproduce in our model the familiar result of the literal target income (LTI) model, that quantity increases to just balance the decrease in income from a fee fall. Section 3 considers the effect of a fee

<sup>3</sup>In Dranove's (1988) model, there are decreasing returns to physician inducement because patients begin to disbelieve their physicians and change physicians. The idea that patients get harder and harder to convince to accept another unit of service is consistent with our model as well. It is not necessary that patients leave a physician's practice for this reaction to limit the extent of physician demand inducement.



change on physician supply when there is more than one fee, originating either from multiple payers or different fees for different services provided to the same payer. We derive expressions for own and cross-price changes in both the model of LTI and the model with no income effects. The relative market shares, margins, time costs, and ease of inducement all play a role in characterizing the physician's response to a fee change. In simulations, we focus on a multiple payer context, and outline the roles of market shares and margins in determining the impacts of fee changes. We call attention to the special vulnerability (under some behavioral assumptions) of a small payer (e.g., a private insurer) with relatively high initial margins to fee reductions introduced by the large payer (e.g., Medicare). Section 4 draws implications for empirical research and policy.

## 2. A base-case scenario: Physician behaviors with one-payer/one-service

This section integrates inducement behavior into a utility framework in which the physician sells a single service at an administratively set price and is concerned with leisure and the disutility of inducement. Literal target income is depicted as an extreme case of income effects in which the income effects at the target income dominate. In contrast, when physicians experience no income effects but still get disutility from inducement, the results are nearly opposite of the LTI case. The empirical case of a negatively sloped physician supply curve, with quantity increases cushioning but not fully offsetting a price cut, is seen to be an intermediate case. (It is not, as we discuss later, evidence for a literal target income model).

In the explicit models of inducement and income targeting that have appeared in the health-care literature to date, the physician is assumed to produce only one service, and the physician often is given the power to set price as well as quantity to achieve the desired income.<sup>4</sup> [Farley (1986); Roehrig (1980)]. No one has yet proposed a complete model of behavior that would apply to the likely future scenario of regulated Medicare prices.

<sup>4</sup>The target-income hypothesis was first proposed to explain the apparent 'restraint' in pricing being exercised by physicians. In cross-sectional studies of physician pricing, higher population-to-patient ratios were associated with lower prices. [See, for example, Newhouse (1970).] One explanation for this is that physicians do not seek to maximize net income, but only to hit a target, and can do so when demand is high with lower prices. Farley (1986) extends the idea of target income and unexploited monopoly power to the case of physician first-degree price discrimination. When facing a downward-sloping demand for a non-storable, non-retradable service, the physician can set price and quantity [McGuire (1983)]. Farley views the physician as setting quantity to maximize the total surplus available, and the target income theory as explaining why in setting price physicians refrain from seizing all social surplus.

By the late 1980s, when physicians were generally constrained in their pricing by fee controls, target-income discussions had undergone a significant shift in tone. The idea that physicians were 'humanitarian' (using Farley's word) was replaced in fee-related context by the idea that physicians pursuing a target income were behaving defensively, in a manner attempting to thwart the social objective of containing health care costs.

Perhaps this neglect occurred because, with a single fee set administratively, the literal target income theory amounts to little more than simple arithmetic: quantity must be set so that the product of quantity multiplied by net price equals the target income. In the LTI model with administered prices and a single service, there are no choices for the doctor to make. The only issue is that of whether the physician would need to engage in demand inducement to achieve the target, or whether demand exceeded the necessary quantity and the physician would hold income *down* to the target by rationing supply.<sup>5</sup>

We begin then by characterizing physician utility maximization with one service and one price. Our model is more general than it needs to be for one service, but it introduces our conception of LTI behavior in the most familiar and easily understood case. We are interested in the relationship between the level of the fee and quantity of services provided. The fee level affects physician income through the margin – fee less cost – on services provided. As the margin changes when the fee changes, the physician may decide to influence quantity provided by changing the extent of demand inducement.

Physician utility is assumed to depend positively on net revenue ( $\pi$ ) and leisure ( $L$ ), and negatively on the amount of demand inducement undertaken ( $I$ ). To keep the mathematics manageable, we assume each argument enters in an additively separable form in utility.<sup>6</sup> Goods in the utility function,  $\pi$  and  $L$ , have diminishing marginal utility, and the ‘bad’ in the utility function,  $I$ , has increasing marginal disutility.<sup>7</sup>

We assume that the physician is a monopolist with a constant number of patients who face a fixed out-of-pocket price (possibly zero) set by regulation. The physician in turn receives a fixed price for his or her service; there is no balance billing allowed. The physician is capable of inducing demand, changing the quantity of services ( $X$ ) patients are prepared to accept at the time and money costs they face for services. Inducement ( $I$ ) can be interpreted in per-patient terms since the number of patients is assumed to be fixed.  $X(I)$  is the total services provided by the physician, with  $X(0) > 0$  and  $X' > 0$ . Since inducement has no natural units, we choose a measure such that  $X'' = 0$ .<sup>8</sup>

Physician services are produced at a constant cost of non-physician time

<sup>5</sup>We have tried to write the last phrase with a straight face.

<sup>6</sup>This implies that the marginal (dis)utility of each argument does not depend on the level of the other arguments. This assumption may be less tenable in the multiple outputs case discussed later.

<sup>7</sup>This is the common formulation of physician utility with inducement. See, e.g., Rice (1984). Evans (1974), in his classic exposition, labelled the LTI model a ‘less formal, non-maximizing’ model, and seems in his discussion to find it a plausible alternative to what he calls the ‘extended maximizing models’. Our main point here is that the LTI model can be reconciled with maximization (although with a somewhat peculiar utility function).

<sup>8</sup>The physician will choose a finite amount of inducement because the second derivative of utility with respect to inducement will be assumed to be negative.

inputs. The physician supplies a time input subject to increasing marginal disutility. Each service provided uses  $t$  units of the physician's time. No substitution is possible between physician time and other inputs.<sup>9</sup> The physician's net revenue depends on the difference between the fee and the cost of other inputs. This is designated by  $m$ , for the 'margin'. With constant costs of non-physician time inputs, an increase in the fee is equivalent to an increase in the margin. The physician maximizes utility by deciding how much inducement to undertake. Inducement determines quantity, and thereby determines net income and leisure.

With these definitions and assumptions, and letting subscripts indicate partial derivatives,

$$U = U(\pi, L, I),$$

where  $\pi = mX(I)$ ,

$$L = 24 - tX(I),$$

$$U_{\pi} > 0, U_L > 0, U_I < 0,$$

$$U_{\pi\pi} < 0, U_{LL} < 0, U_{II} < 0,$$

$$U_{LI} = U_{\pi L} = U_{\pi I} = 0.$$

The first-order condition for utility maximization in the choice of  $I$  is

$$U_{\pi}X'm + U_I + U_L(-X')t = 0. \quad (1)$$

Taking the derivative of (1) with respect to  $m$ , while recalling the assumptions that the cross-partial terms in utility are all zero (from additive separability) and  $X'' = 0$ , and then solving for the effect of a change in margin on inducement,  $I_m$ ,

$$I_m = \frac{-U_{\pi\pi}X(X'm) - U_{\pi}X'}{U_{\pi\pi}(X'm)^2 + U_{II} + U_{LL}(-X't)^2}. \quad (2)$$

In general, the sign of (2) cannot be determined a priori, and it cannot be said whether quantity of services will rise or fall following a fee change. The sign of the denominator is negative, but the numerator has a positive term

<sup>9</sup>In general, a physician might want to change the mode of production as well as the quantity of services supplied in response to a fee change. Introducing limited substitutability would complicate the expressions for response, but not change their character.



$[-U_{\pi\pi}X(X'm)]$  and a negative term  $[-U_{\pi}X']$ . However, more can be said about (2) when implications of LTI and no income effects behavior for the change in the marginal utility of income,  $U_{\pi\pi}$ , are recognized. The LTI case arises when the income effect is very strong. Then,  $U_{\pi\pi}$  is very large, the first (positive) term dominates (2), and a margin fall leads to a quantity rise. In the case of no income effects, the marginal utility of income is constant,  $U_{\pi\pi}$  is zero, the second (negative) term is all that matters, and a margin fall unequivocally reduces quantity supplied.

This simple way of looking at inducement sheds new light on some subtle but important modelling questions. It indicates, first of all, that it is possible to have inducement behavior that stops short of pushing the quantity demanded to its maximum *even if the physician has no concern about a 'target' income whatsoever*. In the case in which there are no income effects on the tradeoff between income and inducement, income always rises when price rises, and falls when price falls; income does not in any sense tend to a 'target', and its level after a price change does not depend on the initial value in any special sense (in contrast to the LTI case). However, the extent of inducement is limited by two influences: the rising marginal disutility of inducement, and the rising marginal disutility of labor. For this model, it would be most correct to say that the physician cares about money income, not about a target income.

Furthermore, the more general model, with some income effects but not of the extreme LTI variety, is a complete economic model. In contrast to the LTI case, it does not require prespecification of an income target, with the uncomfortable question of where the target came from, and why it isn't higher, in order to yield the possibility of an inverse relationship between price and quantity supplied.

Additional insights can be obtained by looking at the two polar case models in more detail.

### 2.1. *Literal target income behavior*

The LTI model is fundamentally a descriptive model, but it can be reconciled with utility maximization, at least in the region of the target income.<sup>10</sup> If the physician is at the target, the LTI model implies that the marginal utility of income or net revenue is very high below the target, and very low above the target. (It is this precipitous drop in marginal utility which holds the physician at the target itself).<sup>11</sup> In other words, one

<sup>10</sup>Away from the target, the LTI model has nothing to say about behavior other than the physician would seek to achieve the target.

<sup>11</sup>There are a number of implausible implications of this form of utility. In a two-good case, as Michael Grossman has pointed out to us, a second derivative of utility equal to negative infinity for one good eliminates any substitution effects in demand.

interpretation of a target income is that *the marginal utility of income is decreasing very fast* in the range of the target. When  $U_{\pi\pi} \rightarrow -\infty$ , only terms multiplied by  $U_{\pi\pi}$  in (2) matter, so (2) simplifies greatly to

$$I_m = \frac{-X}{X'm}. \quad (3)$$

To see that this corresponds to the usual version of LTI behavior, let  $\varepsilon$  be the supply elasticity of  $X$  with respect to a change in the margin. By definition,

$$\varepsilon = \frac{I_m X'm}{X}. \quad (4)$$

In the target income case, substituting (3) into the definition of supply elasticity in (4),  $\varepsilon = -1$ . This is as we would expect. A percentage change in margin must be exactly compensated by an equal and opposite percentage change in quantity for the physician to remain at the target income.

It is easy to see why LTI behavior is disturbing to the payer attempting to control costs by setting physicians' fees. When a fee/margin is reduced, the physician must induce enough demand to make up the shortfall. Because the margin is only a fraction of the price, the percentage quantity increase after a fee reduction is greater than the percentage fall in price. Thus, the payer's total expenditures necessarily *go up* after a fee decrease with an LTI physician.<sup>12</sup>

## 2.2. No income effects

An alternative model with no income effects can be characterized as a kind of 'full profit' maximization, where full profit is revenue less all costs, including the opportunity cost of time, and the subjective cost associated with the unpleasantness of inducement.<sup>13</sup> When 'profit' in this sense is maximized, a change in the level of profits (brought about, for instance, by a lump-sum change in taxes or outside income), even though it reduces net income, does not change behavior. In terms of our model, 'profit maximization' follows when  $U_{\pi\pi} = 0$ , implying that the marginal utility of income is constant, and corresponding to the familiar case of a utility function being characterized by 'no income effects'.

<sup>12</sup>To convert an elasticity with respect to margin to an elasticity with respect to price, multiply by the price/margin ratio. If for example, the physician's margin over short-run variable costs is 40 percent, the supply elasticity with respect to price implied by LTI is  $-2.5$ .

<sup>13</sup>The reconciliation of profit maximization and utility maximization along these lines has been discussed in a series of articles in the *Southern Economic Journal*. See Formby and Millner (1985) and the references cited there.



With  $U_{\pi\pi}=0$ , (2) also takes a definite sign. The denominator remains negative, and the only term in the numerator,  $-U_{\pi}X'$ , must also be negative.  $I_m$  is therefore positive. Thus, as would be expected with an upward-sloping supply curve, a decrease in margin or fee decreases inducement unambiguously, reducing quantity.

### 2.3. When does a decrease in fee increase volume?

Our model of physician behavior can be used to set out rigorously the condition under which (in the one-payer case) a fee cut increases quantity supplied. It is not necessary (although it is a sufficient condition) for the physician to seek a target income for this relation to appear in a one-service model. Volume responds in a 'perverse' fashion to a price change if (2) is negative, which will be the case when the numerator of (2),  $-U_{\pi\pi}X(X'm) - U_{\pi}X'$ , is positive. Noting that  $\pi = Xm$ , the condition is<sup>14</sup>

$$-U_{\pi\pi}\pi/U_{\pi} > 1. \quad (5)$$

Eq. (5) is the condition that the income effect,  $U_{\pi\pi}$ , is 'large enough' to lead to a negatively sloped supply curve.

Notice that, as price is cut and the profit margin shrinks, this expression must eventually become negative. As  $\pi \rightarrow 0$ , the numerator goes to zero, but the denominator does not. If price is cut sufficiently close to cost, further price reductions *must* display a normal rather than a perverse response. Volume offsets are therefore symptomatic of price levels well above resource costs.<sup>15</sup>

In sum, the strength of the income effect differentiates the LTI, negatively sloped supply, and 'full profit maximization' models. All three versions of physician behavior can be viewed as turning, other things equal, on a single parameter,  $U_{\pi\pi}$ , the change in the marginal utility of income. When this change is very very large (and negative), the physician seeks a target income. When the income effect is strong but not quite so dominant, the physician still exhibits the feared volume-increasing response to price cuts.<sup>16</sup> When  $U_{\pi\pi}$  is very small, the physician acts like a profit-maximizing firm. Estimating the size of the income effects may therefore help give guidance to the size and direction of possible volume responses to a contemplated price cut.

<sup>14</sup>Interestingly, the condition for the supply curve to be backward bending involves the coefficient of relative risk aversion [the left-hand side of (5)], a measure of the curvature of the income-utility schedule. The supply curve is negatively sloped if and only if the coefficient of relative risk aversion exceeds one.

<sup>15</sup>We are indebted to Thomas Hoerger for this point.

<sup>16</sup>It should be noted that income could remain unchanged after a fee change, in behavior that could look like pursuit of a target. In a simple labor/leisure choice model, a wage fall, depending on the strength of income and substitution effects, could lead to a rise, fall, or no change in income.

### 3. Multiple services and prices

In the more relevant multiple-payer case, income effects are joined by substitution effects across services, as well as the substitution effect between money and leisure that motivated the single-service case. In this case, the physician has alternative avenues through which to pursue income through demand inducement.

Suppose a single payer, call it Medicare, reduces the fees it pays for all services provided to its beneficiaries. What happens to Medicare quantity?<sup>17</sup> One conclusion from the previous section immediately carries over. If income effects are zero, the volume of the service for which price is cut necessarily decreases. Beyond this, however, the two-payer case becomes more complex. To the substitution effect between income and inducement that prevailed in the one-service case must now be added the possibility of substituting inducement for another, relatively more profitable service.

Thus, the dictum that LTI physicians will always achieve the target income by increasing the quantity of a service whose price is cut is no longer correct in the multiple-service world. There are now an infinite number of ways to hit a target by blending demand inducement across all markets. On the one hand, a Medicare fee cut reduces income, so if physicians pursue a target income, they will tend to increase the demand they induce for all services (the 'income effect' of a fee change). On the other hand, after the fee reduction in a service, there will be less return to the physician to inducing demand for that service from Medicare beneficiaries relative to other patients, encouraging the physician to induce less for that service and more in other markets (the 'substitution effect').<sup>18</sup>

What are the circumstances in such a model in which lowering a price for one service or a set of services leads physicians to respond with an increase in the quantity of that service? What determines whether the increase in quantity is likely to be small or large? What are the factors that determine what a change in *another* payer's prices will mean for a particular payer's quantities?

<sup>17</sup>In the Medicare context, and in the case of some private plans, the physician response can have several elements. Behaviors that will change include: 'participation' in the plan, billing over the fee, supply of services, coding, and the manner of producing services. While all are potentially important, the most important and controversial is the supply of services. First, it is the most important for social cost. Second, unlike the other behaviors, where at least the direction of the effect of a price change can be reasonably foreseen, even the question of the *direction* of the effect of a price change of supply is unresolved.

Economic models designed to address the impacts of fee changes on these 'other' aspects of physician behavior generally employ a model with no income effects (physicians maximize profit) and in which physicians cannot induce demand. See, for example, Glazer and McGuire (1990), Wedig et al. (1989), or Zuckerman and Holahan (1991).

<sup>18</sup>Physician response to a fee change is commonly discussed in terms of the income and substitution effects, see, for example, Wedig et al. (1989), Rice and Labelle (1989), and Pauly (1991).

We now consider the case in which the physician produces more than one output. This case, developed mathematically for two services, applies both to a single payer buying two services, or to two payers covering a single output. The two-service model is

$$U = U(\pi, L, I_1, I_2),$$

where

$$\pi = X_1(I_1)m_1 + X_2(I_2)m_2,$$

$$L = 24 - X_1(I_1)t_1 - X_2(I_2)t_2.$$

As before, profit and leisure are goods, and inducement for service 1 or 2 decreases utility. Margins, time inputs, ease of inducement, and unpleasantness of inducement may all differ as between service 1 and service 2. These factors capture most of what might motivate differential physician responses to margin changes across different services. A service with a higher margin, lower time cost, more responsiveness to inducement, and less unpleasantness of inducing, can be expected to bear a relatively high share of the burden of maintaining a target income.

Decreasing marginal utility for all arguments means that all second derivatives are negative. This utility function is assumed to be additively separable in all arguments so cross-partial terms are zero.

Letting  $U_1$  and  $U_2$  represent derivatives of utility with respect to inducement in markets 1 and 2, the FOCs for utility maximization are

$$U_\pi X'_1 m_1 - U_L X'_1 t_1 + U_1 = 0, \quad (6)$$

$$U_\pi X'_2 m_2 - U_L X'_2 t_2 + U_2 = 0. \quad (7)$$

We are interested in the change in equilibrium described by (6) and (7) as the relative margins of the different services are changed. Some observations about these effects can be made before deriving formal mathematical expressions for the effect of margin changes.

Consider a decrease in  $m_1$  (e.g., a cut in the Medicare fee for some procedure). What effect will this have on  $X_1$ , the Medicare service, and  $X_2$ , the service provided to other payers? The effect on  $X_1$ , the Medicare service, has already been described in the one-service model. The only difference in the two-service case is that a given cut in the Medicare margin will have a smaller effect on total income, since the Medicare share is less than 100 percent. Thus the likelihood of a negatively sloped supply curve for this service is reduced. (To be sure, there may be some price cut sufficiently large to have a strong income effect). In general, the bite of a price cut will decline



with market share, and, for a small-share payer, the substitution effect of a change in one price can be expected to dominate physician response.

How will a reduction in  $m_1$  affect  $X_2$ ? When income effects are absent and either the marginal utility of leisure is unchanged or the time component for  $X_1$  is very small, we get a surprising conclusion: there will be no effect on  $X_2$ . In order for  $X_2$  to be affected, there must either be income effects or the marginal utility of leisure must be changed by the change in  $m_1$ . Positive income effects are easy to understand: a decline in income increases  $U_\pi$ , and a physician finding him or herself poorer is willing to induce more for all services. If the effect of the cut in the margin on  $X_1$  is to reduce  $X_1$ , then devoting less labor to service 1 may decrease the marginal disutility of labor, making inducement for  $X_2$  more attractive.

The case of zero income effects and no effect on the marginal utility of labor, therefore, is one in which cutting price for a service is likely to be the best way to get the quantity of a service reduced, *and* have the effect of the price cut stay confined to that service. In contrast, unwanted spillover effects are most likely when income effects are strong.

Another vehicle for cross-service effects is through interactions of the disutility for various types of inducement. Specifically, suppose that inducement levels for various services (or for the same service for various payers) are close substitutes in the utility function, and it is simply the total amount of inducement undertaken that concerns the physician. If income effects are zero, a decline in Medicare's price for some service calls forth less inducement for that service. This decline in turn reduces total inducement, and potentially results in a lower marginal disutility for inducement for other services. The consequences of this for inducement will depend on the specific form of the cross effects.

Cross effects of a different form will be introduced if we model the disutility constraint on inducement by assuming that the physician is concerned about patients' utility. Reducing inducement for the lower-priced services raises both Medicare patients' utility and the average utility of all patients, Medicare and non-Medicare. The marginal effect of inducement for other services on physician income will be unaffected, so that the physician will choose to offset part of the increase in patient utility with more inducement. This approach suggests that more of the inducement will be concentrated on other Medicare services – since the utility of Medicare patients is raised by the initial response to the price cut. But if the utility of one type of patient substitutes for the utility of other types of patients in the physician's own utility function, there will be some spillover effect on non-Medicare patients as well.

It should be kept in mind, therefore, that the discussion which follows only applies under our assumption of zero cross effects with respect to inducement in the utility function.

Table 1

Own and cross-price elasticities, no income effects and literal target income.

Own-price, no income effects

$$\varepsilon_{\pi 11} = \frac{\delta[(\gamma\tau)^2 + \beta\alpha]}{(\gamma\tau)^2 + \beta + \beta\alpha}.$$

Own-price, literal target income

$$\varepsilon_{TI 11} = \frac{-[(\gamma\tau)^2 + \beta\alpha - \alpha\delta(\gamma\rho)^2] + \rho\gamma^2\tau}{(\gamma\tau)^2 + \beta\alpha + (\gamma\rho)^2 + \alpha(\gamma\rho)^2 - 2\rho\gamma^2\tau}.$$

Cross-price, no income effects

$$\varepsilon_{\pi 12} = \frac{-\rho\gamma^2\tau\delta}{(\gamma\tau)^2 + \beta + \beta\alpha}.$$

Cross-price, literal target income

$$\varepsilon_{TI 12} = \frac{-\rho\sigma[(\gamma\tau)^2 + \beta\alpha] - \delta\alpha(\gamma\tau)^2 + \tau(\gamma\rho)^2\sigma}{(\gamma\tau)^2 + \beta\alpha + (\gamma\rho)^2 + \alpha(\gamma\rho)^2 - 2\rho\gamma^2\tau}.$$

Note: Parameter definitions are listed in the glossary at the end of the paper.

Further analysis is possible once we obtain expressions for the effect of a change in  $m_1$  on  $X_1$  and  $X_2$ , using comparative static techniques. We therefore differentiate (6) and (7) with respect to  $m_1$  and  $m_2$ , and solve for  $\Delta_{11}$ , the effect of a change in  $m_1$  on  $I_1$ , and  $\Delta_{12}$ , a change in  $m_1$  on  $I_2$ . These are then converted into elasticity terms, expressing the percentage change in quantity supplied in terms of the percentage change in the margin:  $\varepsilon_{1i} = X'_1 \Delta_{1i} m_i / X_1$ ,  $i=1,2$ . Derivations are contained in the Appendix, and the results are shown in table 1.

As a check on these expressions for own and cross elasticities in the case of an LTI, note that if a target income is to be maintained, the total change in income with respect to a change in any margin, say  $m_2$ , must be zero. Thus, from the definition of net income, if there is a target income,

$$\varepsilon_{12}(m_1 X_1 / m_2 X_2) + \varepsilon_{22} = -1. \quad (8)$$

It is straightforward (but tedious) to show that the expressions in table 1 satisfy condition (8) for the LTI model.<sup>19</sup>

Unfortunately, the expressions in table 1 are extremely complex, reflecting

<sup>19</sup>When verifying this, note that the expression in table 1 is for  $\varepsilon_{11}$ . The expression for  $\varepsilon_{22}$  is found by substituting  $\delta_{22} = \delta_{11}\rho\gamma^2/\sigma\beta$ , and inverting all other parameters. The expression for  $\varepsilon_{12}$  can be used as is from the table.

the many factors that we recognize in the model as affecting the physician's decision about how much to engage in demand inducement. The parameterization of response we have chosen starts with the response of inducement for service one ( $I_1$ ) to a change in the margin for service one ( $m_1$ ), and then uses variables measuring the situation of service two relative to service one to describe behaviors of interest. The parameter  $\delta$  describes the upward slope of a physician's supply curve if only the increasing disutility of inducement were to restrict supply. (See the Glossary for a formal definition for all parameters). The parameter  $\alpha$  describes the importance of the increase in the disutility of labor relative to the disutility of inducement as output is expanded through demand inducement. Thus, by choice of  $\alpha$  and  $\delta$ , one could pick models in which various combinations of increasing marginal disutility of labor and inducement limit output. Note that if  $U_{LL}=0$  (marginal utility of labor is constant), then  $\alpha$  will become infinite. The cross-price elasticity, with no income effects, will then equal zero, as discussed above.

A series of other parameters,  $\beta$ ,  $\gamma$ ,  $\sigma$ ,  $\rho$ , and  $\tau$ , describe the values of the change in the marginal disutility of inducement, response to inducement, size of markets, margins, and time costs, respectively, for service two relative to service one. In any particular application, one or more of these factors may be important in anticipating the impact of a fee change. We briefly discuss here an example of how each of these parameters might come into play, in situations in which the two outputs are interpreted as different services for the same payer, or two payers and one type of service. We then analyze in detail two factors of special interest, market share and relative margins.

The elasticity  $\beta$  describes the relative rate of increase in disutility from inducement of the two types of service.  $\beta$  might vary if the clinical criteria for performing one service were more clear-cut in relation to another. A physician may be more comfortable inducing demand for a longer hospital stay for a childhood psychiatric disorder than for an appendectomy. The relative response of demand to inducement  $\gamma$  may vary with the patient's insurance coverage. Patients paying less out-of-pocket may more easily accept recommendations for more care.

The relative size of the markets  $\sigma$  is important for determining the strength of the income effect of a fee change relative to a substitution effect, and to the return on the per-patient inducement in the market. Relative margins  $\rho$  and relative time costs  $\tau$  describe the profitable and low-time cost services to induce. Thus, a very appealing target for inducement might be laboratory tests, where the marginal cost is low in relation to the fee, and the physician's time cost is also very small.

Market share and margins are characteristics of the payers, rather than describing the nature of the service itself, or the nature of the physician's utility, and are therefore of special concern for purposes of policy. To study



the role of these two variables in more detail, we fix values of other variables at a base level, and alter market shares and margins under the two polar-case behavioral hypotheses of LTI and no income effects.<sup>20</sup> The complexity of the expressions in table 1 means the relationships are best studied using numerical methods.

In Figs. 1, 2, and 3, we vary market share and relative margins. Fig. 1 depicts the situation when a large payer, with a market share of 80 percent, changes its fees. The dotted lines show the consequences in one extreme case of no income effects. Relative margins do not affect behavior (since only substitution effects count). Own-margin elasticity ( $\varepsilon_{11}$ ) is positive but small. The cross effect ( $\varepsilon_{21}$ ) is negative and small as well. The cross effect is present because of the change in the marginal utility of leisure from the increase in output in sector one. In the case of no income effects and a marginal utility of leisure that does not increase steeply, this effect is negligible.

In contrast, when the physician pursues a literal target income, behavior changes are more dramatic. The 'classic' LTI behavior is observed at the far left in fig. 1a. When Payer 2's margins are much lower than Payer 1's the physician will seek to recover income almost exclusively through inducement to Payer 1. The  $-0.99$  own-margin elasticity when Payer 2's margin is 50 percent less than Payer 1's is close to what would occur in a one-payer model. Matters improve for Payer 1 and deteriorate for Payer 2 as Payer 2's margin is higher in relation to Payer 1.

When margins are originally equal, the physician induces demand substantially in both markets. If the margin of the large payer is less than the small payer, as might generally be expected to be the case, the small payer suffers badly. When the small payer's margin is 50 percent higher, the large payer's fee change causes a very large percentage change in the quantity of output to the small payer.

Fig. 2 shows the situation when the payers are equal in size. In rough terms, Payer 1 might represent the public payers, and Payer 2 all private payers in the U.S., considered as a single entity. Again, with no income effects, a fee reduction by Payer 1 reduces its output with only a small percentage increase imposed on Payer 2. With very strong income effects, however, a different story emerges. The relevant range in Fig. 2 is probably where Payer 2's margin exceeds Payer 1's. When the margin is 30, 40, 50 percent higher than Payer 1's, Payer 1 essentially has no worry about demand inducement due to target income. Almost all the burden falls on Payer 2.

<sup>20</sup>The parameter  $\delta$  is 0.05. Relative disutilities of inducement ( $\beta$ ) and response to inducement ( $\gamma$ ) are proportional to market share (recall these are in per capita terms). The services consume equal time ( $\tau=1$ ), and the increase in the disutility of labor is equally important as the increase in the disutility of inducement in restricting supply absent income effects ( $\alpha=1$ ).

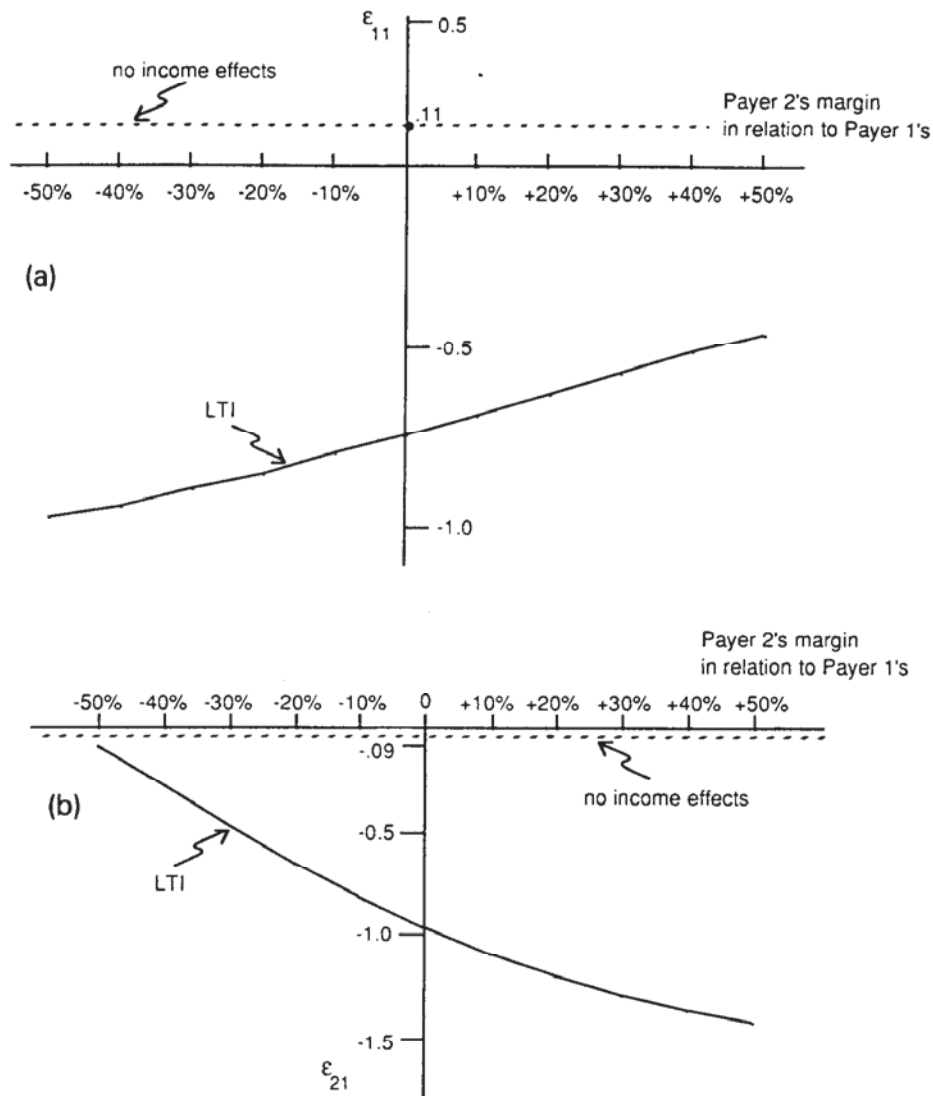


Fig. 1. Own and cross elasticities and relative margins when a large payer changes fee.

When the small payer changes fee, substitution effects matter most for the impact on the small payer, as shown in Fig. 3. Payer 1 in this figure has a market share of 20 percent. When Payer 1's margin is less than Payer 2's, the output response is *positive* in the case of LTI, and can actually be more

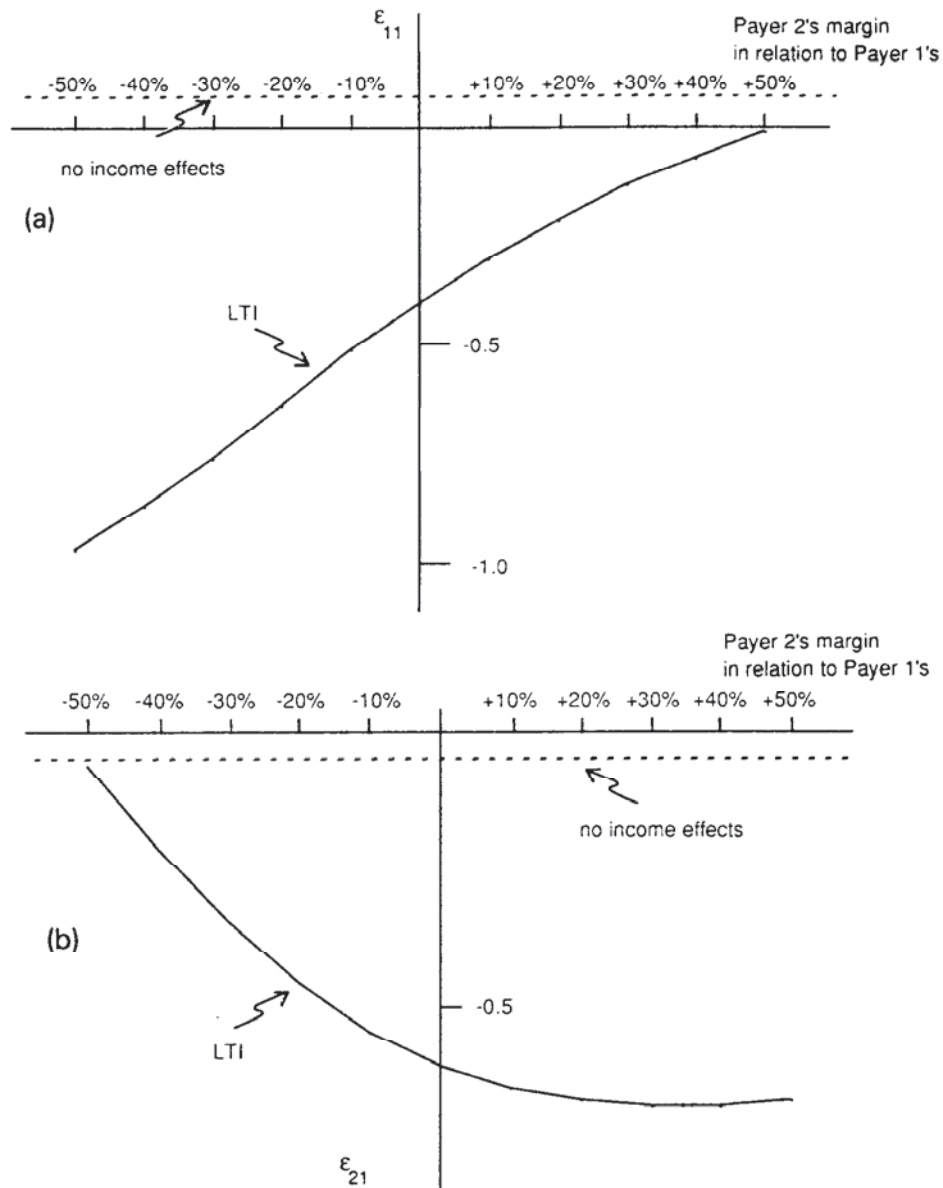


Fig. 2. Own and cross elasticities and relative margins when a moderate size payer changes fee.

positive than with the no income effects case. The reason for this is that the large effort shifted to Payer 2 raises the marginal disutility of labor for Payer 1. The large payer (Payer 2 here) suffers from some demand inducement, but



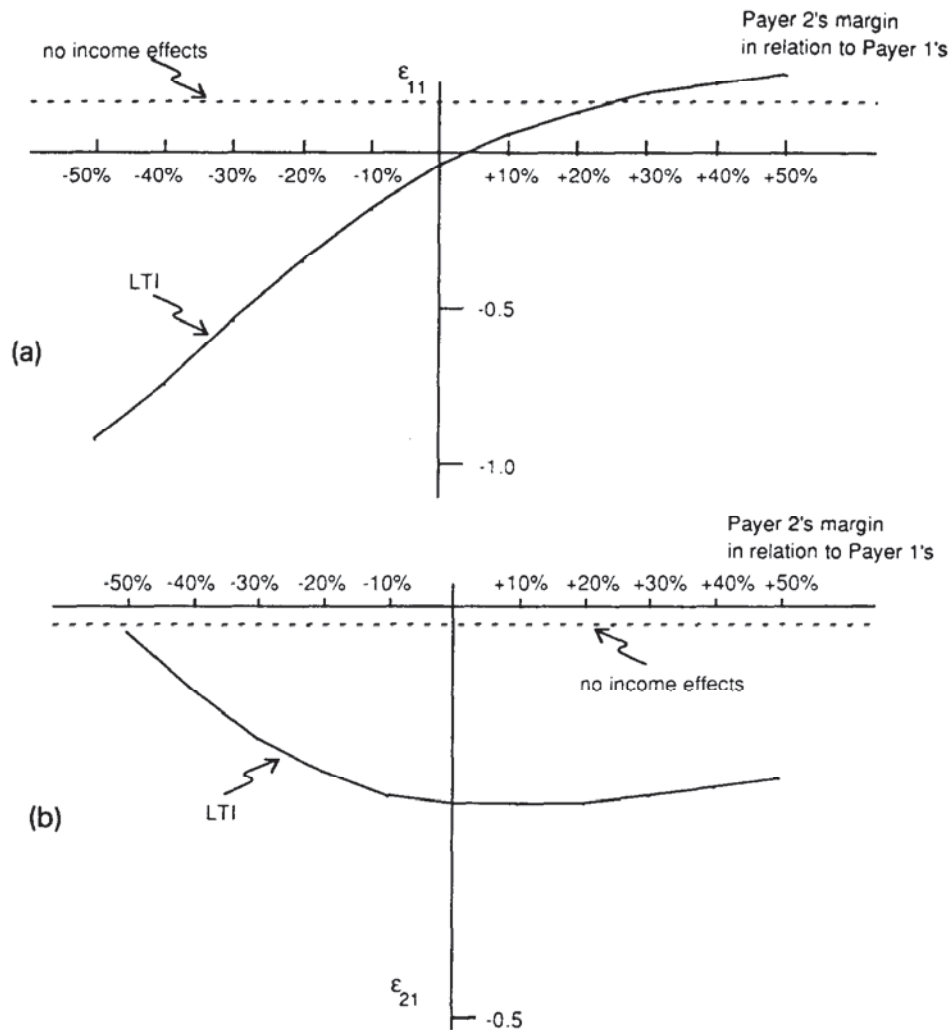


Fig. 3. Own and cross elasticities and relative margins when a small payer changes fee.

this is relatively small, since the income effect of a fee change by the small payer is itself small.

Even when the physician behaves according to the LTI hypothesis, the magnitude and sign of the expected quantity response will depend on the market share, and relative margins of the payers involved. Other factors, such as the relative ease of demand inducement in the different markets, will matter as well, although they have remained in the background in the analysis presented here.

## 4. Implications for policy and research

### 4.1. *Implications for policy*

Policy makers are of two minds when it comes to the expected response of physicians to a fee change. 'Usual' economic markets respond to an exogenous price fall with a supply decrease. Such an expectation lies behind much of current public and private fee policy: fees will be reduced for groups of procedures for which fees currently greatly exceed costs (surgical procedures are usually cited as examples here) in the hopes of reducing the supply of these services. But with entry and exit slow in the short run, and existing physicians pursuing a 'target income', the opposite may happen. In response to a policy that would reduce their net income, doctors may induce demand from their patients to maintain the target. To guard against this, Medicare employs a 'target expenditure' policy, based on the assumption that half of price cuts will be offset by volume increases.

When income effects are minor, these 'perverse' effects of fee changes are unlikely and cross-payer effects are of little concern. When income effects are important (and some physician ability to induce demand is assumed as well), possible perverse cases arise, and cross-payer effects of fee changes also become important.

These ideas can aid fee policy. Given the state of the evidence, it would be prudent for policy makers to be aware of both the income and substitution effects of policy changes. Income effects are not a procedure-level effect; they occur at the practice or physician level. Income effects will be most pronounced for physicians with a large share of their practice devoted to procedures with large fee cuts. A Medicare fee cut for lens procedures will generate more of an income effect for ophthalmologists than the same percentage fee cut for a procedure done by general surgeons, because ophthalmologists derive a greater share of their income from Medicare. From Medicare's point of view, a quantity increase after a fee cut, if any is to occur, is more likely to come from such specialties. Other payers can also recognize where potential income effects are likely to be strong. The simulations presented here (based upon a particular set of assumptions about the form of physicians' utility) give some idea of the magnitude of the likely responses.

Private payers would be hardest hit by any income-effect driven volume responses from Medicare fee changes if two circumstances coincide: (1) at the practice level, physicians' income would be adversely affected by Medicare's changes, and (2) at the procedure level, the margin paid by the private payer is much higher than the Medicare margin.

Medicare, in turn, would be affected by the fee policies of other payers. Proposals to raise Medicaid fees (possibly to Medicare levels) would work

against any income effect generated by Medicare fee reductions, and should mitigate volume responses. Large payers, like Medicare, can expect other payers to react to their policy changes. Any analysis of optimal fee policy must include anticipation of the reaction of other payers.

#### *4.2. Empirical research: Target incomes or income effects?*

At this point, we use two perspectives from the model just described in order to comment on the empirical literature studying physician response to fee changes and target income. The first is that LTI is an extreme form of income effects; the latter can exist without implying the former. The second perspective is that with multiple payers, the predictions of the LTI theory depend critically on the market share of the payer changing price. With these points in mind, we can ask: Is there evidence for income effects in physician supply? Is the evidence strong enough to support the idea of a target income?

A large number of papers have interpreted time trends or geographical differences in prices and quantities in terms of the target-income hypothesis. [See Wedig, Mitchell and Cromwell (1989), Rice and Labelle (1989), and Feldman and Sloan (1989) for an exchange discussing the most important of these]. One problem in making sense of these results is that these are typically observations about markets, whereas the hypothesized behavior is at the physician level. So many factors change over time that affect physician behavior that examination of trends at the state or national level is unlikely to help differentiate the competing hypotheses.

Estimates of pure income effects offer the most direct test of the LTI hypothesis. If there are no income effects, there can be no negative response to price changes. Exogenous shifts in physician non-practice income can isolate the income effect on physician behavior. Hurdle and Pope (1989) studied the determinants of productivity and work effort of physicians in 1975–1984 using HCFA-NORC data. A dummy variable indicating that the physician had unearned income greater than \$10,000 reduced the total number of hours worked by three percent, controlling for physician age and other characteristics, but the effect was statistically insignificant ( $t=1.38$ ). This is weak evidence for a positive income effect. Physicians' net income in the mid-1980s was about \$90,000, so even if the Hurdle and Pope point estimate is taken as accurate, a three percent reduction in effort would not reduce net income from practice enough to fully offset the unearned income, as the LTI model would predict. An earlier study by Sloan (1975) obtained roughly the same result: a positive but numerically small and statistically insignificant effect of non-practice income on physician supply and work.

Rice (1984) and Hurley, Labelle and Rice (1990) have studied the impact of administered fee changes on the volume of physician billings. In 1977,



Colorado set Medicare fees on the basis of state-wide averages, reducing fees for the previously higher-paid physicians in the Denver-Boulder metropolitan area, and increasing them for other physicians. For some specialties, Rice (1984) found that changes in the intensity of services provided per encounter and changes in the quantity of visits provided per surgical episode were inversely related to the fee-level changes, with elasticities in all cases less than one in absolute value. Hurley, Labelle and Rice (1990) followed the volume of provincial billings in Ontario over the period 1975–1987 for 28 procedures. They found no discernible pattern in the positive and negative responses to fee changes with utilization measured in various ways.

The results of the second study are not surprising. As the discussion around fig. 3 shows, when a price is changed for a service that constitutes only a small part of total billings, *both* the LTI and profit-maximizing models would predict a positive response. As specified, the Rice et al. investigation of the Ontario case could not differentiate between the two theories. More generally, our analysis indicates that empirical specification of physician response should include a measure of the income effect of a price change, as well as the price change itself (the substitution effect). The income effect measure would reflect all the set of prices changing for a physician, and weight the importance of these by their share in the total practice. In the Ontario case, without knowing which physicians were adversely affected in an overall sense by the price changes, it is not surprising that the LTI model could not be tested.

The earlier Colorado natural experiment contains results consistent with strong income effects. Although Rice's paper doesn't include the critical information about market shares and margins, presumably Medicare's share of the studied specialties ranged from ten to perhaps 50%, and Medicare's margins were probably less favorable than other payers. In these circumstances, the LTI model predicts (see figs. 2, 3) that the elasticity of response to margin is negative and between 0 and  $-1$ . When converted to a price elasticity (by dividing by the ratio of price to margin), the relatively small negative coefficients found by Rice (1984) are consistent with income effects. Unfortunately, without direct measures of an income effect, and missing some key variables, it is difficult to draw conclusions with confidence.

An obvious implication of this discussion is that independent empirical determination of the magnitude of the income effects on inducement or supply behavior more generally would be extremely valuable. Such a direct test would be preferable to the indirect approach of trying to estimate supply responses.

As a final comment, we recommend dispensing with the idea that the 'target income' hypothesis is an alternative to 'profit maximization' in empirical research. As we have argued, the empirical issue is better phrased in terms of the *magnitude* of income effects, not in terms of income effects

being either completely dominant (as in LTI) or completely absent (as in profit maximization). With better measurement of the strength of income effects, empirical specifications will better reflect theory, and include a proper measure of the income effect of a set of fee changes, not simply the series of price change measures included in most multiple regression work to date. This will facilitate integrating empirical research on physician supply with empirical research on labor supply. The 'target income' hypothesis is scorned, in our view correctly, by many economists. Health economists can debate the size of income effects, without having to explain the absurd behavior which underlies the literal target income hypothesis.

### Glossary

Own and cross-price elasticities are expressed in terms of a number of parameters. They are defined here using the terms of the physician's utility function and the definitions in the text.  $U_{ii}$  designates the second derivative of utility with respect to inducement for service  $i$ .

$\delta = -m_1(X'_1)^2 U_{\pi}/X_1 U_{11}$	Supply elasticity of service 1 when only disutility of inducement restricts supply (no increase in disutility of labor).
$\alpha = U_{11}/[(X'_1 t_1)^2 U_{LL}]$	For service 1, the relative importance of the increase in disutility due to inducement and loss of leisure following an increase in inducement for service 1.
$\beta = U_{22}/U_{11}$	The ratio of second derivatives of disutility from inducement for services 2 and 1.
$\gamma = X'_2/X'_1$	The response of demand to inducement for service 2 compared to 1.
$\sigma = X_2/X_1$	Relative size of markets in quantity terms.
$\rho = m_2/m_1$	Relative margins.
$\tau = t_2/t_1$	Relative time costs.

### Appendix: Own and cross-price effects under profit maximization and LTI

The total differentials of eqs. (6) and (7) from the text are

$$A_{11} dI_1 + A_{12} dI_2 + A_{13} dm_1 + A_{14} dm_2 = 0, \quad (A.1)$$

$$A_{21} dI_1 + A_{22} dI_2 + A_{23} dm_1 + A_{24} dm_2 = 0. \quad (A.2)$$

Recalling that  $U_{ii}$  is the second derivative of utility with respect to  $I_i$ , the  $A_{ii}$  coefficients are

$$A_{11} = U_{\pi\pi}(X'_1 m_1)^2 + (X'_1 t_1)^2 U_{LL} + U_{11},$$

$$A_{12} = U_{\pi\pi} X'_1 m_1 X'_2 m_2 + X'_1 t_1 X'_2 t_2 U_{LL},$$

$$A_{13} = U_{\pi\pi} X'_1 m_1 X_1 + X'_1 U_{\pi},$$

$$A_{14} = U_{\pi\pi} X'_1 m_1 X_2,$$

$$A_{21} = U_{\pi\pi} X'_1 m_1 X'_2 m_2 + X'_1 t_1 X'_2 t_2 U_{LL},$$

$$A_{22} = U_{\pi\pi}(X'_2 m_2)^2 + (X'_2 t_2)^2 U_{LL} + U_{22},$$

$$A_{23} = U_{\pi\pi} X'_2 m_2 X_1,$$

$$A_{24} = U_{\pi\pi} X'_2 m_2 X_2 + X'_2 U_{\pi}.$$

Cramer's rule can be applied to solve for  $\Delta_{11}$  ( $\equiv dI_1/dm_1$ ) and  $\Delta_{12}$  ( $\equiv dI_1/dm_2$ ). These partial derivatives are converted into own and cross-price elasticities,  $\varepsilon_{11}$  and  $\varepsilon_{12}$ .

#### A.1. Own-price elasticity

In terms of the above coefficients,

$$\Delta_{11} = \frac{-A_{13}A_{22} + A_{12}A_{23}}{A_{11}A_{22} - A_{12}A_{21}}. \quad (\text{A.3})$$

$\Delta_{11}$  can be converted to elasticity terms by multiplying by  $X'_1 m_1 / X_1$ . After cancelling terms and dividing top and bottom by  $U_{\pi\pi}$ ,

$$\varepsilon_{11} = \frac{-\{(X'_1 m_1)^2[(X'_2 t_2)^2 U_{LL} + U_{22}] + (m_1(X'_1)^2 U_{\pi}/X_1)[(X'_2 m_2)^2 + X'_2 t_2)^2 U_{LL}/U_{\pi\pi} + U_{22}/U_{\pi\pi}]\} + X'_1 t_1 X'_2 t_2 X'_1 m_1 X'_2 m_2 U_{LL}}{(X'_1 m_1)^2[(X'_2 t_2)^2 + U_{22}] + (X'_1 t_1)^2 U_{LL}[(X'_2 m_2)^2 + (X'_2 t_2)^2 U_{LL}/U_{\pi\pi} + U_{22}/U_{\pi\pi}] + U_{11}[(X'_2 m_2)^2 + (X'_2 t_2)^2 U_{LL}/U_{\pi\pi} + U_{22}/U_{\pi\pi}] - [2X'_1 m_1 X'_2 m_2 X'_1 t_1 X'_2 t_2 U_{LL} + (X'_1 t_1)^2 (X'_2 t_2)^2 (U_{LL})^2 / U_{\pi\pi}]} \quad (\text{A.4})$$

*A.1.1. Case: Profit maximization:  $U_{\pi\pi} = > 0$*

When  $U_{\pi\pi}$  goes to 0, only terms in (A.4) with  $U_{\pi\pi}$  in the denominator will matter, yielding,

$$\varepsilon\pi_{11} = \frac{-[m_1(X'_1)^2 U_{\pi}/X_1][(X'_2 t_2)^2 U_{LL} + U_{22}]}{U_{11}(X'_2 t_2)^2 U_{LL} + U_{22}(X'_1 t_1)^2 U_{LL} + U_{11}U_{22}}. \quad (\text{A.5})$$

Dividing by  $(X'_1 t_1)^2 U_{LL} U_{11}$  and replacing terms by designated parameters yields the expression in the text.

$$\varepsilon\pi_{11} = \frac{\delta[(\gamma\tau)^2 + \beta\alpha]}{(\gamma\tau)^2 + \beta + \beta\alpha}. \quad (\text{A.6})$$

*A.1.2. Case: Target income:  $U_{\pi\pi} = > -\infty$*

In this case, terms with  $U_{\pi\pi}$  in the denominator go to zero, yielding,

$$\varepsilon TI_{11} = \frac{-\{(X'_1 m_1)^2 [(X'_2 t_2)^2 U_{LL} + U_{22}] + (m_1(X'_1)^2 U_{\pi}/X_1)(X'_2 m_2)^2\} + X'_1 t_1 X'_2 t_2 X'_1 m_1 X'_2 m_2 U_{LL}}{(X'_1 m_1)^2 [(X'_2 t_2)^2 + U_{22}] + (X'_1 t_1)^2 U_{LL}(X'_2 m_2)^2 + U_{11}(X'_2 m_2)^2 - 2X'_1 m_1 X'_2 m_2 X'_1 t_1 X'_2 t_2 U_{LL}}. \quad (\text{A.7})$$

Dividing by  $(X'_1 m_1)^2 (X'_1 t_1)^2 U_{LL}$  and using the parameter definitions yields the expression in the text.

$$\varepsilon TI_{11} = \frac{-[(\gamma\tau)^2 + \beta\alpha - \alpha\delta(\gamma\rho)^2] + \rho\gamma^2\tau}{(\gamma\tau)^2 + \beta\alpha + (\gamma\rho)^2 + \alpha(\gamma\rho)^2 - 2\rho\gamma^2\tau}. \quad (\text{A.8})$$

*A.2. Cross-price elasticity*

Applying Cramer's rule to solve for  $\Delta_{12}$ ,

$$\Delta_{12} = \frac{-A_{14}A_{22} + A_{12}A_{24}}{A_{11}A_{22} - A_{12}A_{21}}. \quad (\text{A.9})$$

$\Delta_{12}$  can be converted to elasticity terms by multiplying by  $X'_1 m_2/X_1$ . After cancelling terms and dividing top and bottom by  $U_{\pi\pi}$ ,



$$\varepsilon_{12} = \frac{-\{[(X'_1)^2 m_1 m_2 (X_2/X_1)][(X'_2 t_2)^2 U_{LL} + U_{22}] + (X'_2 m_2 X'_1 U_{\pi}/X_1)[X'_1 m_1 X'_2 m_2 + X'_1 t_1 X'_2 t_2 U_{LL}/U_{\pi\pi}] + X'_1 t_1 X'_2 t_2 X'_1 m_2 X'_2 m_2 (X_2/X_1) U_{LL}\}}{\text{same as (A.4)}}. \quad (\text{A.10})$$

*A.2.1. Case: Profit maximization:  $U_{\pi\pi} = > 0$*

When  $U_{\pi\pi}$  goes to 0, only terms in (A.10) with  $U_{\pi\pi}$  in the denominator will matter, yielding,

$$\varepsilon\pi_{12} = \frac{(X'_2 m_2 X'_1 U_{\pi}/X_1)(X'_1 t_1 X'_2 t_2 U_{LL})}{\text{same as (A.5)}}. \quad (\text{A.11})$$

Dividing by  $(X'_1 t_1)^2 U_{LL} U_{11}$  and replacing terms by designated parameters yields the expression in the text.

$$\varepsilon\pi_{12} = \frac{-\rho\gamma^2\tau\delta}{(\gamma\tau)^2 + \beta + \beta\alpha}. \quad (\text{A.12})$$

*A.2.2. Case: Target income:  $U_{\pi\pi} = > -\infty$*

In this case, terms with  $U_{\pi\pi}$  in the denominator go to zero, yielding,

$$\varepsilon TI_{12} = \frac{-\{[(X'_1)^2 m_1 m_2 (X_2/X_1)][(X'_2 t_2)^2 U_{LL} + U_{22}] + (X'_2 m_2 X'_1 U_{\pi}/X_1)(X'_1 m_1 X'_2 m_2) + X'_1 t_1 X'_2 t_2 X'_1 m_2 X'_2 m_2 (X_2/X_1) U_{LL}\}}{\text{same as (A.7)}}. \quad (\text{A.13})$$

Dividing by  $(X'_1 m_1)^2 (X'_1 t_1)^2 U_{LL}$  and using the parameter definitions yields the expression in the text.

$$\varepsilon TI_{12} = \frac{-\rho\sigma[(\gamma\tau)^2 + \beta\alpha] - \delta\alpha(\gamma\tau)^2 + \tau(\gamma\rho)^2\sigma}{(\gamma\tau)^2 + \beta\alpha + (\gamma\rho)^2 + \alpha(\gamma\rho)^2 - 2\rho\gamma^2\tau}. \quad (\text{A.14})$$

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