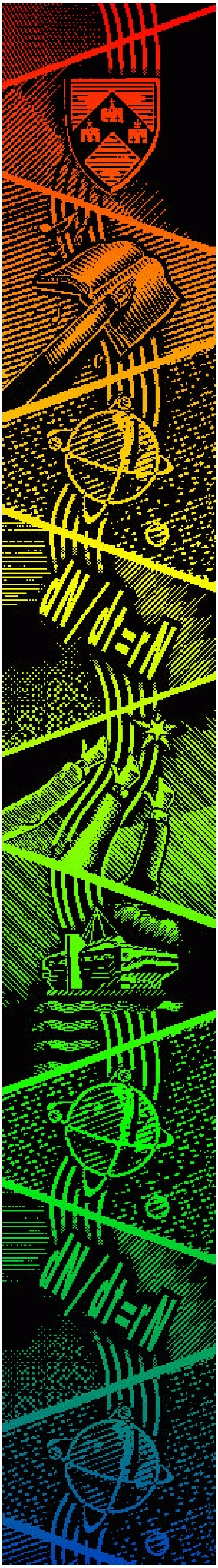

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Managing Demand in Primary Care: The Market for Night Visits

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Managing Demand in Primary Care: The Market for Night Visits

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Abstract

We analyse the demand for and the supply of night visits in primary care. A model of demand management by general practitioners and of their choice between meeting demand by making visits themselves or passing them to commercial deputising services is presented. Demand and supply equations are derived and estimated using panel data from English primary care health authorities over the 1984-1994 period. The introduction of differential fees for GP and deputy visits in April 1990 led GPs to increase their own visits and to reduce the number made by deputies. GPs also responded by either reducing efforts to manage demand downwards or increasing efforts to induce demand. GPs manage demand downwards in response to exogenous demand increases. We also find that demand is not affected by the likelihood that the visit is made by a GP or a deputy, suggesting that patients do not perceive these visits as being of differential quality.

Keywords: Primary care, night visits, demand management.

JEL classification: I11

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1. Introduction

Out of hours primary care[1] in the English National Health Service (NHS) is provided by a variety of services and professionals, including general practitioners (GPs), accident and emergency departments (A&E), ambulance services, evening nurses, social services, pharmacists and dentists. GPs and A&E departments are the most important, both in terms of the proportion of the total out of hours care provided and resources used.

Certain features of the health care provision of out of hours primary care services in England make it an interesting setting to explore physician responses to incentives. First, out of hours care provided by a practice to its patients is one of the few examples in the NHS of remuneration on a simple fee for service basis. Second, patients do not face charges for care so their demand for night visits from their GPs is not directly affected by changes in the fees paid to GPs. Consequently, it may be easier to examine the extent to which doctors influence the demands made by their patients. Third, GPs may themselves provide out of hours care for the patients on their list (being on call during the night or via rotas with other GPs) or they may pass on the calls from their patients to deputising services. In the latter case GPs must then pay the deputy for the out of hours visits made. Since the supply of visits by GPs can be less than the number of visits demanded by patients we have further scope for disentangling demand and supply sides when examining the data generated by the market.

This paper provides a modelling framework to examine factors influencing the supply of and the demand for out of hours care in primary care. We use the model to examine the extent to which it is possible to disentangle supply and demand factors and to guide our estimation of supply and demand functions in the market for primary care in the NHS using an area level panel data set for 1984/5-1994/5. Explicit modelling is essential to understand the data on demand and supply generated by the market and to assess the impact of policy changes. By modelling and estimating the demand and supply functions we can address three principal questions:

- how does the supply of night visits by GPs respond to changes in the fees for night visits?

[1] The definition of out of hours care is, to some extent, arbitrary since surgery hours vary across practices (Hallam, 1994). In our empirical work we use the definition adopted by the remuneration system.

- To what extent do GPs influence the demand for night visits by their patients?

- Do patients appear to care whether night visits are made by their GP or by a deputy?

The effect of the fees paid to GPs on the supply of night visits is of obvious importance for policy makers attempting to predict the effects of fee changes on NHS expenditure and on the services provided to patients. Much of the interest in the extent to which doctors influence the demand from their patients has focused on the question of whether doctors attempt to increase patient demand to boost their incomes (Labelle et al, 1994). However, GPs may also wish to reduce demand for out of hours visits to patients since these are widely perceived to impose much heavier costs on GPs than consultations during normal office hours, and in the NHS doctors do not have the option of rationing demand by raising prices to patients.

In April 1990 the NHS introduced differential payments to GPs for night visits made by the GP or by a doctor from a deputising service. This was an explicit attempt to reduce the amount of night visiting carried out by deputies rather than by patients' own GPs. The rationale for the change was that visits by GPs were thought to be of higher quality than those by deputies, because the latter would be less well informed about the patient. However, it is not clear whether patients share this perception (Dixon and Williams, 1988; McKinley et al., 1997). We attempt to provide some indirect evidence by testing whether demand is affected by the likelihood that a visit is made by a deputy. If this is not the case, the rationale for differential payments for visits by GPs and deputies is weakened.

In the next section we describe the organisation of out of hours primary care. We also discuss the related literature and distinguish our contribution. In Section 3 we model a market for primary care night visits with a demand side in which demand may depend on the proportion of night visits by deputies and GPs' demand management and a supply side in which GPs must decide whether to encourage or discourage demand, and how much demand to meet themselves and how much from deputies. We derive comparative static responses to demand and supply side exogenous variables, including night visit fees and examine the circumstances in which increases in exogenous demand make GPs worse off. Section 4 describes the data. Section 5 estimates the demand and supply equations in the light of the theoretical model and discusses the result. Section 6 contains our conclusions.

2. Out of hours primary care in the NHS

2.1 Background

GPs are responsible for the primary care of their patients on a 24 hour basis. Night visits are one of the few general practice services remunerated on a fee for service basis. A £1 fee per night visit was introduced in April 1967 (equivalent to £9.39 in 1995 prices). In subsequent years the fee increased in real terms and was £20.25 in 1989/90 (£25 in 1995 prices). The 1990 GP contract introduced two major changes in out of hours remuneration. First, the time over which visiting fees could be paid was extended from 23.00-7.00 hours to 22.00-8.00 hours. Second, a differential fee for visits was introduced: a fee of £45.00 was paid for a night visit by the patient's GP and a lower fee of £15.00 was paid to the GP if the visit to their patient was made by a deputy.

Table 1 shows that the national average night visits rate has risen from 43 visits per 10,000 population in 1967 when the £1 fee per visit was introduced (Buxton et al., 1977) to 196.6 in 1989 and 357.5 in the 1994-95 financial year (NHS Executive, 1996). Even if we allow for the possibility that GPs did not claim for all visits in the early years of the system when the fee was very low, the increase is dramatic and has prompted debate as to the extent to which it is due to patients becoming more demanding or to changes in GPs' demand management.

Most GPs regard out of hours work as a negative aspect of their medical career (Rowsell, 1995). Out of hours calls, especially night calls are described as a source of stress and many feel that family life is constantly interrupted by telephone calls (Rout, 1996). It is not surprising that GPs are keen on reducing their personal availability (Scott, 1999) and have used alternative arrangements for out of hours care delivery (Lattimer et al., 1996). Especially in urban areas, where the density of the population made them economical, there was a rapid growth of deputising services. The majority of GPs used these commercial services to free themselves of night work for at least some days of the week (Dopson, 1971). In more recent years there has been a growth of co-operatives of GPs to provide out of hours care for their patients (Hallam and Cragg, 1994).

Table 2 shows the proportion of night visits made by deputising services. In 1989-90 almost half of the night visits were made by deputies. The new remuneration system introduced in April 1990 discouraged the use of deputising services, and the proportion of night visits made by deputies decreased to 30.8% in 1990-91. Subsequently, the proportion of night visits made by deputies rose again to 38.5% in 1994-95.

2.2 Previous studies of the market

Previous studies have been almost entirely based on a single cross section, either at practice level or at area level and have related the rate of night visits to a variety of supply and demand side variables. Majeed et al. (1995) analysed the claims for night visits among GPs in Merton, Sutton and Wandsworth (an area in London) and found that the night visits rate was positively associated with the proportion of the practice population aged under five years, and the proportion chronically ill. Night visits were negatively related to the proportion of the practice population aged between 35 and 44 years and to list inflation (the difference between the number of patients on practice lists in an area and the population estimated from the population census). Whynes and Baines (1996) examined the variation in night visit rate among practices in Lincolnshire and found a positive relationship with the number of maternity claims per GP, the number of patients per GP, the number of home visits per GP, the number of other practices within a one mile radius, and the unemployment rate. Carlisle et al. (1993) found that the variation in night visit rates among different wards within one general practice was significantly associated with the Jarman and Townsend deprivation scores and unemployment rates. Cubitt and Tobias (1983), comparing out of hours calls between two similar practices in London, found that differences in night visits rates were mainly related to differences in the doctor's attitude and response towards minor symptoms.

There have been three studies at the level of the administrative unit for primary care, Family Health Service Authorities (FHSAs)[2], where data is more readily available. Buxton et al. (1977) and Baker and Klein (1991) found that characteristics of FHSAs populations which were positively associated with night visit rates included the proportion of the population in lowest social class, the standardised mortality ratios, and the proportion of elderly patients. Practice characteristics such as the proportion of GPs aged over 65, the ratio of practice nurses to GPs, and the proportion of practitioners with lists sizes below 1000 patients, were

[2] Before April 1990 the 90 FHSAs, each with around 500,000 patients, were called Family Practitioner Committees but had the same geographical composition. In what follows references to FHSAs should be understood to cover FPCs where appropriate. In April 1996 FHSAs were reorganised into 100 new Health Authorities which combined responsibility for secondary and primary care.

negatively related with night visiting rates. Conversely, practice characteristics positively associated with night visiting rates included the proportion of GPs with permission to use deputising services. Baker et al. (1994) compared FHSAs' night visiting rates, before and after the change in the contract in April 1990. The study allowed for the effects of socio-economic and demographic characteristics of FHSAs by cluster analysis rather than multiple regression. They found that GPs increased their own night visiting activities and reduced their reliance on deputising services and these changes varied across clusters. For example, the increase in the number of night visits was greatest in the most affluent cluster.

Some of the previous analyses have distinguished between demand and supply factors (Buxton et al., 1977; Baker et al., 1994). However, single equation cross section models in which the night visit rate is regressed on a mixture of variables which might affect supply and demand side decisions are problematic. They yield results which are difficult to interpret because they are derived from a reduced form equation or are biased because of the inclusion of variables, such as the proportion of GPs with permission to use deputising services, that are potentially endogenous.

We believe our paper makes a number of contributions to the literature. We specify a theoretical model which clearly distinguishes demand and supply sides of the market and derive comparative static predictions. Our data is a panel rather than a single cross section and we get more of the information from the data by using multiple regression rather than cluster analysis. The estimations are guided by our formal model. We show that it is possible to estimate the structural supply equation and that although it may not be possible to identify the demand equation we can obtain some guidance as to the likely biases in estimated coefficients. We also test for demand management by GPs.

3. A model of the market for night visits

3.1 Demand for night visits

The demand for night visits in an area depends on patients' valuations of the health gains and thus on characteristics of the population such as age and health status. Patients do not face charges for night visits but their demand will depend on the costs of alternative sources of out of hours of care, for example the travelling, waiting and treatment time for a visits to a pharmacy or accident and emergency department. We indicate these exogenous demand factors by a vector *x*.

Demand depends on GPs' demand management activity *a* which will be discussed in the next section. Demand may also be affected by whether visits are made by the patient's GP or a commercial deputising service. Patients may place a higher value on visits made by a physician who knows their health history than on visits made by deputising physicians. Patients perceive the quality of night visits *q* as depending on the number of visits made by GPs and by deputies

$$q = q(g, n - g) \qquad q_1 > 0,\ q_2 < 0 \tag{1}$$

where *g* is the number of visits by GPs and *n* is the total number of night visits.

The demand function can be written as

$$n = D(x, a, q) \qquad D_x > 0,\ D_a \gtrless 0,\ D_q > 0 \tag{2a}$$

or, allowing for (1), as[3]

$$n = n(x, a, g) \qquad n_x > 0,\ n_a \gtrless 0, 0,\ n_g > 0 \tag{2b}$$

3.2 Supply decisions

GPs are constrained to meet the total demand for night visits from their patients but they can attempt to manage demand positively or negatively. A practice must also decide how much of the demand to meet themselves and how much to meet by passing calls onto a deputising service. We ignore the distinction between the different means of GPs meeting demand themselves such as own visits, shared rotas, or joining a cooperative.

GP preferences are described by a utility function $u(p,L,a)$, where p is practice income, $L(g)$ is leisure and a is demand management activity. GP visits reduce leisure but deputy visits do not: $L' < 0$.

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[3] Using $n - D(x,a,q(g,n - g)) = 0$ we have $n_g = D_q(q_1 - q_2)/(1 - D_q q_2)$, $n_x = D_x/(1 - D_q q_2)$ and $n_a = D_a/(1 - D_q q_2)$.

Passing a call onto a deputising service reduces the net income of the practice. A visit made by a deputy attracts a fee for the practice, but the practice must pay the deputising service. Thus even when the NHS remuneration regime paid the same fee to the practice irrespective of who made the visit, the net fee for a visit by a deputy f^d was less than the fee for a visit by the GP f^g. After 1 April 1990 the fee paid to the practice by the NHS for a deputy visit was reduced to one third of the fee paid for a visit made by a GP.

Practice income is

$$p = gf^g + (n-g)f^d - c(n,z) + y \tag{3}$$

where c is the practice cost function ($c_n > 0, c_{nn} > 0$), y is other practice income, and z is a vector of exogenous practice characteristics. Using (2b) the effect of an additional visit by a GP on practice income is

$$p_g = f^g - f^d + (f^d - c_n)n_g \tag{4}$$

GPs can induce their patients to request more night visits, for example by making it easier to contact the practice out of hours. They can also discourage demands by educating patients about making requests for visits for "trivial" reasons. Such demand management activity is costly to GPs whether demand is encouraged or discouraged ($u_a < 0$).[4]

GP and deputy visits cannot be non-negative and must sum to equal demand. Hence the Lagrangean for the GP's problem of choosing GP visits and demand management activities is $u + l[n(g,a,x) - g]$ and the first order conditions are, with complementary slackness:

$$u_p p_g + u_L L' + l\left(n_g - 1\right) \le 0, \qquad g \ge 0 \tag{5}$$

$$u_p(f^d - c_n)n_a + u_a + l n_a \le 0, \qquad a \ge 0 \tag{6}$$

$$n(x,g,a) - g \ge 0, \qquad l \ge 0 \tag{7}$$

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[4] To be more precise, we should define a as a vector (a_1,a_2) with a_1 being demand reducing activity ($n_{a1} < 0$), a_2 being demand inducement activity ($n_{a2} > 0$), with the activities being distasteful ($u_{ai} < 0$) and mutually exclusive ($a_1 a_2 = 0$).

Making the appropriate assumptions to ensure the concavity of *u* in *g* and *a*, the first order conditions define the optimal number of GP visits $g^* = g(x, z, f^g, f^d)$ and the amount of demand management $a^* = a(x, z, f^g, f^d)$. Substituting into the demand function gives the equilibrium number of visits $n^* = n(x,g^*,a^*)$, and visits by deputies $n^* - g^*$. There are nine types of market equilibrium depending on whether GPs pass all their visits to deputies, do some visits or do all visits and whether they engage in demand management and if so whether they induce or reduce demand.

The type of demand management activity undertaken is determined by whether visits are profitable at the margin. Suppose that the GP undertakes all visits and does not use the deputising service so that the constraint $n \geq g$ binds. Substituting for l in the condition on *a* and rearranging gives

$$\left[u_p\left(f^g - c_n\right) + u_L L'\right]n_a + u_a = 0 \qquad (7)$$

If $f^g \leq c_n$ the square bracketed term is negative and the GP will only wish to engage in activities to reduce demand ($n_a < 0$). Conversely he will only wish to induce demand ($n_a > 0$) if additional visits are profitable ($f^g > c_n$). Whether demand is managed will depend on the magnitude of $u_a(p,L,0)$.

When the GP makes use of the deputising service to meet demand, the effect of demand management on utility is $u_p(f^d - c_n)n_a + u_a$. If $f^d < c_n$ the practice will not want to increase demand and may engage in demand reducing activities. Conversely if $f^d > c_n$, inducement activity ($n_a > 0$) is profitable though it may not be undertaken if highly distasteful at the margin.

Figure 1 illustrates the decision on how to meet exogenous demand of *n* in a simple case in which demand is not affected by perceived quality and there is no demand management activity. If the GP meets all the demand by using deputies he is at *k* where $g = 0$ and $p = y - c(n) + f^d n$. If he meets the demand entirely by GP visits he is at *m* where $g = n$ and $p = y - c(n) + f^g n$. Increases in *g* reduce leisure so that GPs' preferences can be shown in (g,p) space as indifference curves like I_1.

In the example shown the GP chooses b_1 on the constraint line *km* which has slope $f^g - f^d$. With a less strong relative preference for leisure (flatter indifference curves) the optimal point might be b_2 or even at *m* where he meets all demand without using the deputising service.

3.3 Comparative statics

Consider the effect of simultaneous increase in f^g and reduction in f^d (as happened in 1990/1). The new constraint line in Figure 1 is k_1m_1 which cuts the old constraint line *km* and has a steeper slope. If there is no income effect the GP would increase *g* and reduce deputy visits (as expected by policy makers). But suppose that leisure is a normal good. If the GP was initially at b_2 he is made better off and the income effect will, at least partially, offset the substitution effect: the GP may reduce the number of visits he makes and pass more calls to his deputising service. Conversely, if the GP is initially at b_1 he is made worse off by the fee changes, the income effect will reinforce the substitution effect and the proportion of visits made by the GP will increase.

Figure 2 illustrates the effect of an increase in exogenous demand from *n* to n_1 when the GP uses the deputising service to meet part of the demand. Income when only deputies are used changes by $f^d(n_1 - n) - \Delta c$ and when no deputies are used by $f^g(n_1 - n) - \Delta c$, where $\Delta c = c(n_1) - c(n)$. The constraint line is shifted up or down by demand increases depending on whether f^d exceeds or is less than the marginal cost of extra night visits. In the case shown $f^d < c_n(n)$ and the GP is made worse off by the demand increase. If leisure is a normal good he will increase the number of visits he makes but the proportion of visits by deputies may increase or decrease.

We can also make use of Figure 2 to gain some intuition for incentives to engage in demand management. Starting from demand of *n*, all points to the left of *n* have lower incomes when demand increases if $f^d < c_n(n)$. Hence if the initial position is to the left of *m* (so that $g < n$) the GP is made worse off by the demand increase. He will therefore not wish to engage in an activity (demand inducement) which he dislikes for its own sake and which results in an unfavourable shift in his income leisure opportunity boundary. Indeed if demand is initially at n_1 he gets a more favourable income leisure constraint line by managing demand down to *n*. If his marginal dislike for demand management is not too great he would be better off by engaging in demand reduction from n_1 to n.

If he was initially at m and meeting all demand himself he may be made better off by the increase in demand provided that m_1 generates higher income than m, which requires that $f^g > c_n(n)$. When $f^g > c_n(n)$, GPs who meet all demand without recourse to deputising services will not wish to discourage demand and may be better off by inducing it.

Definite comparative static predictions require restrictions on the specification of technology, demand and preferences. Table 3 reports the effects of changes in demand conditions x which increase demand ($n_x > 0$), the fees f^g, f^d paid for night visits and the cost parameter z which increase marginal cost ($c_{nz} > 0$). To derive the definite results in the table we assume that GP preferences are quasi linear in income and additively separable so that there are no income effects, that there are no quality effects on demand ($n_g = 0$), and that the effect of demand management is independent of the level of the demand shift parameters x ($n_{xa} = 0$).

The table shows the effect of increases in the exogenous variables on the number of visits made by GPs and on the level of demand via demand management $n_a \partial a/\partial k$ ($k = x, f^g, f^d, z$). Note that we are interested in the sign of the product $n_a \partial a/\partial k$ rather than the signs of its components because we do not observe demand management, only its effects on demand. The effect of an exogenous variable on demand via demand management could be positive either because the practice increases its demand inducement or because it reduces its attempts to restrain demand. The table covers the six possible cases in which there is demand management and, when $n_a \partial a/\partial k$ is set to zero, the three cases in which there is no management of demand.

We observe the aggregated responses of all practices in an area, rather than individual practices so that the size of observed response depends on the distribution of practices across the cases. However, we can make qualitative predictions where the responses in the different cases are of the same sign or are zero. Thus we see that exogenous increases in demand will, in aggregate, increase the number of visits by GPs but lead to a change in demand management which reduces the impact of the demand increase. The net effect on demand, allowing for changes in demand management, is positive but less than the direct effect. The fact that we cannot observe demand management activities directly will lead to downward bias on the estimated effects of exogenous demand shifters on demand. The intuition for $n_a \partial a/\partial x < 0$ when the practice is engaged in demand inducement (n_a > 0) is that an exogenous increase in demand enables it to reduce the level of a distasteful activity (demand management): $\partial a/\partial x < 0$. When the practice is restraining demand (n_a < 0) visits are costly at the margin and the increase in demand increases the marginal gain from demand reduction and so demand management increases: $\partial a/\partial x > 0$

The aggregate effect of exogenous increases in marginal cost is intuitive. With a higher marginal cost the practice will wish to reduce demand and so will either increase efforts to reduce demand ($n_a < 0, \partial a/\partial z > 0$) or reduce efforts to increase it ($n_a > 0, \partial a/\partial z < 0$). The reduced number of night visits will be met either by a reduction in deputy visits (cases (*i*) and (*ii*)) or a reduction in GP visits (case (*iii*)).

Increases in the fee for visits by GPs leads to an increase in the number of visits by GPs in practices where GPs make at least some visits. It does not affect the incentives for demand inducement unless GPs make all visits themselves. Thus the aggregate effect of the fee increase is to increase visits by GPs and the management of demand to increase demand.

Increases in the fee for deputy visits have no effect on behaviour where all visits are made by the GP. If the GP uses the deputising service to meet some of the demand an increase in the fee for a deputy visit leads to a change in demand management which results in an increase in demand. The number of visits by deputies increases and so does the proportion of visits by them.

Figure 3 illustrates the impact of the 1990/1 increase in fees for GP visits and reduction in fees for deputy visits. A practice initially at m_1 and not using any deputies will be able to move to m_2 with the same demand. It is even better off managing a demand increase to n_1 and moving to m_3. Conversely a practice initially at b_1 is made worse off and would be at b_2 if it made no response. It can leave the level of demand unchanged, increase the number of visits made by GPs and move up the constraint line b_2m_2. By managing a demand reduction to n_2 it may do even better by shifting the constraint line upwards to b_3m_4 so that demand falls and the number of visits made by GPs increases. The overall effect of the simultaneous increase in f^g and reduction in f^d is to increase the number of visits by GPs. The effect on the level of demand is less clear since practices with a low proportion of visits by GPs will manage demand downwards and those with a high proportion will manage demand upwards.

3.4 Do demand increases make GPs better off?

In standard industrial economics models increases in the demand makes suppliers better off. But GPs have been complaining for many years about increasing demand from their patients for out of hours visits (Rivett, 1998, p. 412). We can use the model to explain this apparent paradox as arising from the facts that GPs must meet demand and have no ability to raise fees to patients as an alternative means of choking off demand.

The marginal effect of an increase in the demand shift parameter on the GP's maximised utility is, making use of the envelope theorem

$$\frac{\partial u}{\partial x} = u_p\left(f^{d} - c_n\right)n_x + \lambda n_x \qquad (8)$$

In the case in which a GP does not make all the night visits ($g < n$) the GP is worse off if the net fee for a deputy visit is less than the marginal cost of a visit since the Lagrange multiplier is zero and $u_p > 0$, $n_x > 0$. If the GP does not use deputies the constraint $n \geq g$ binds and $\lambda > 0$ so that the second term is negative. If the GP does not engage in any demand management activity the effect of demand increases is ambiguous. In terms of Figure 2 he moves from m to m_1 and m_1 may be above or below the indifference curve through m. If the GP does manage demand then we can substitute for λ from the first order condition on a to get

$$\frac{\partial u}{\partial x} = -\frac{n_x}{n_a}u_a \qquad (9)$$

Now $u_a < 0$ and so we have the intuitive result that the GP is made worse off by the increase in demand if he is already attempting to manage demand downwards ($n_a < 0$). Conversely, a GP who is inducing demand ($n_a > 0$) is made better off by demand increase. Hence we see that the model predicts that GPs may indeed be made worse off as demand increases.

4. Data

The data used are from the Health Service Indicators (HSI) database (NHS Executive, several years) and cover 11 financial years (April to March) from 1984/5 to 1994/5. The unit of analysis is the FHSA.

The night visits rate, n_{it}, is expressed as the annual night visits rate per 10,000 population. From April 1990 the period over which visiting fees could be paid increased from 23.00-7.00 hours to 22.00-8.00 hours. We therefore follow Buxton et al. (1977) and adjust the number of night visits to allow for the change in the number of hours for which visit fees could be claimed. The effect of the adjustment is scale down the number of night visits from 1990/1 onwards.

The exogenous population characteristics x_{it} are the proportions of FHSA population aged 0-4 and aged 75 or older, and the age and sex standardised mortality rate. Increases in the proportion of the FHSA population aged 5 or younger, aged 75 or older and in the standardised mortality rate are expected to increase the number of night visits demanded. We also include the pharmacy density (measured by the ratio between the number of community pharmacies and the FHSA area) to allow for differences in the accessibility to alternative sources of out of hours care. We expect density of community pharmacies to be negatively associated with demand for night visits.

We use the proportion of visits by deputies as a measure of the quality of night visits and expect that increases in the proportion reduce demand. Before 1990/1 night visits by deputies were remunerated at the same rate as visits by GPs and consequently data on deputy visits was collected only biannually and some areas did not collect the information at all (see Table 2). Regressions including our measure of quality are therefore based on 691 rather than 990 observations.

The supply of visits by GPs g_{it} is expressed as the number of night visits exclusively made by GPs per physician (adjusted by the number of hours over which fees were paid).

The exogenous primary practice care characteristics z_{it} are the ratio of practice nurses to GPs, the proportion of GPs who are solo practitioners, the proportion of GPs older than 65, the number of GPs per head of the population and the population density. We expect that a higher ratio of practice nurses to GPs will leave GPs free to make more night visits. Single handed GPs may have higher costs of making night visits since they cannot organise rotas with their partners. We also expect older GPs to find night visits more of a strain and to make fewer of them. GPs in areas with higher population density are expected to make more visits because of lower travel and time costs. Finally, we anticipate that GPs with smaller list sizes will be less busy during office hours and be more willing to make out of hours visits.

Night visit fees are fixed centrally by the Department of Health and do not vary across areas. GPs are influenced both by the level of the fees for night visits but also by the relative size of the fees for visits by deputies and GPs. There was no difference in the fees prior to 1990/1 and after 1990/1 the ratio of GP visit fee to deputy visit fee was kept close to 3. Consequently the correlation between the fees paid to GPs and deputies is extremely high (0.9985). Further, the large change in the relative sizes of the fees occurred at the same time (April 1990) as the large increase in the fee paid for GP visits. We could not satisfactorily disentangle the effects of the change in the level and the ratio of the fees and in the estimated equations we include only the fee for night visits f^g.[5]

We include time trends in the estimated demand and supply equations to pick up the effects of gradually evolving influences which we are not able to measure (such as changes in patient preferences or GP attitudes). Table 4 has descriptive statistics of all variables included in the analysis.

5. Estimation results: supply of night visits by GPs

The model of GP behaviour developed in the section 3 yields the optimal supply of GP visits and GP demand management as functions of exogenous variables affecting demand by patients, characteristics of GPs and their practices, and the fees for night visits by GPs and deputies: $g^* = g(x, z, f^g, f^d)$, $a^* = a(x, z, f^g, f^d)$. We do not have data on demand management activities but we can estimate the supply function for GP night visits. We do however test for demand management activities in our estimation of the demand equation and the effects of the 1990/1 fee changes (see section 6.5).

To choose the functional form of the supply function we compared linear and the log-linear specifications using the Box-Cox (1962) and the PE tests (Mackinnon et al., 1983). The Box-Cox test rejected both specifications, but the $\chi^2(1)$ statistics of the linear form was much

[5] Hughes and Yule (1992) encountered similar problems analysing the effects of changes in fees on the numbers of maternity care and cervical cytology treatments. We found that using the ratio of GP to deputy visit fees gave very similar results to using the GP visit fee.

smaller than for the log-linear case: 55.79 versus 409.99. The PE test accepts the linear specification but rejects the log-linear specification. We accordingly preferred the linear specification. We also tested for a structural break in 1990/1 by running separate regressions without the fee variable for the period before and after April 1990 and found that the estimated coefficients did not differ significantly.[6]

Table 5 reports the results for the supply equation

$$g_{it} = b_0 + \sum_{j=1}^{J} b_j z_{itj} + \sum_{k=1}^{K} a_k x_{itk} + b_f f_t^{\,g} + d_1 t + d_2 t^2 + v_{it} \qquad (10)$$

in which the supply of night visits in FHSA i at time t is a function of exogenous characteristics of the providers z_i , exogenous characteristics of the population and of the area x_{it} , the GP night visits fee $f^{\,g}$ and time trends.

As the data consist of pooled cross-sectional annual observations over time we use panel data estimators. We allow for omitted time-invariant variables that are specific to individual FHSAs by using a fixed effects estimator (Baltagi, 1995). Although a fixed effects model sacrifices a large number of degrees of freedom, the Hausman (1978) test suggests that the alternative random effects model is not appropriate because the FHSA effects are correlated with time varying area variables.

The results suggest that the demand side characteristics are important in determining the night visits supplied by GPs, although the signs of the demand coefficients vary. For instance we observe that the proportion of children and aged 75 or older is positively related with the night visits supplied, while the coefficient on the SMR is negative. This does not in itself imply that the model is inappropriate since it is only versions of the theoretical model with restrictions on preferences or technology that predict that all demand characteristics will have the same qualitative effect on the supply of night visits by GPs. However the RESET test suggests that the regression is misspecified.

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[6] The null hypothesis that the coefficients estimated in the two periods were not systematically different was not rejected by a Hausman test: $\chi^2(9) = 9.74$, $p. = 0.372$.

As a possible solution to the misspecification we can replace the individual demand characteristics with a variable derived from them. Consider a model in which the proportion of visits by deputies does not affect demand (which we find in section 6 is the preferred demand model). For given *a* demand is fixed and the optimal supply of GP visits conditional on *a* is $g^{\circ}(z, n(a,x), f^{g}, a)$. We can estimate

$$g_{it} = b_0 + \sum_{j=1}^{J} b_j z_{itj} + b_n n_{it}^{g} + b_f f_t^{g} + d_1 t + d_2 t^2 + u_{it} \qquad (11)$$

OLS is not a suitable estimator for (11) because actual demand n_{it}^{g} is endogenous and correlated with unobserved demand management activities. We estimate (11) using IV with exogenous demand side variables used as instruments for the potentially endogenous actual demand variable.[7]

Table 6 presents the parameter estimates of the supply equation and compares the OLS results with those from the IV estimation. The exogeneity test indicates that the IV estimator is preferable to OLS. The signs of most of the estimated coefficients are in line with the expectations. Only the coefficient of the variable measuring the ratio between practice nurses and GPs has an unexpected negative sign.

Comparing the estimated coefficient for the variable measuring the demand for night visits per GP, we notice that the coefficient estimated using IV is significantly larger than the one obtained using OLS. We can interpret this as evidence that GPs manage patients' demand downward in response to an exogenous increase in demand. The OLS coefficient measures the effect on physicians' supply of night visits of an exogenous increase in demand after physicians' have managed patients' demand. The OLS coefficient picks up both the direct effect of the exogenous demand change and the effect of demand management. The IV estimate gives the effect of an increase in the demand after we have purged the management

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[7] We have selected the relevant instruments using two criteria: first to maximise the F-statistic of the identifying instruments in the first stage regressions (see Bound et al., 1995; and Staiger and Stock 1997); second, to pass the overidentifying (OID) restrictions test, also known in the literature as Sargan-Hansen-Newey or *J-tests* (see Godfrey and Hutton, 1994). Using this procedure we used as instruments the proportion of the population aged 4 or less, aged 75 or more and pharmacy density. The first stage F-statistic was F(3,590) = 7.94 and the OID restrictions test was not significant.

effect. Since the IV coefficient is larger than the OLS one, we argue that physicians respond to upward demand shocks by managing demand downwards.

6. Demand for night visits

In the theoretical model of section 3 we considered the implication of patient demand depending on the proportion of visits by deputies, as a measure of perceived quality, and on GPs' demand management. This has implications for the way in which the demand function should be estimated and we explore these by reporting the results of four types of demand specifications.

Model 1 assumes demand is entirely exogenous, Model 2 has demand affected by the proportion of visits made by deputies, and Model 3 has demand affected by demand management. Model 4 allows for both demand management and endogenous quality.

The Box-Cox (1962) and the PE tests (Mackinnon et al., 1983) of functional form are inconclusive. The RESET test suggests that the linear models suffer from serious miss-specification. We therefore chose the log-linear form which passed the specification test in most of the models.

6.1 Model 1: Exogenous demand

The simplest specification of the demand equation assumes that the demand is exogenous and is not influenced by GPs, either directly via demand management or indirectly by their decision on how much of demand to meet by using deputising services. The empirical specification is

$$\ln n_{it} = a_0 + \sum_{k=1}^{K} a_k x_{itk} + d_1 t + d_2 t^2 + e_{it} \qquad (12)$$

Demand for night visits in FHSA *i* at time *t* is a function of exogenous characteristics of the population and of the area x_{it} and a time trends.

The first two columns of Table 7 show the exogenous demand equation estimated using all the 990 observations available. The second part of the table present the same model estimated on only the 691 observations for which there was information on the number of night visits by deputies. The latter results can be compared more directly with the specifications in which the proportion of visits by deputies is included as a quality measure. The estimates are not greatly affected by the number of observations. The Hausman tests show that the fixed effects models are better specifications than the random effects models and the F-tests on the FHSA specific effects show that panel data models are superior to a simple pooled regressions.

The coefficients on the x_{it} are biased estimates of the effects of x_{it} on demand because of unobserved demand management $a(x,z,f)$. There are two problems. First, the theoretical model shows that increases in demand may lead GPs to manage demand downwards or reduce attempts to increase demand. Hence the coefficients on x_{it} are biased downwards, although the theoretical model (see Table 3) suggests that this source of bias will not lead to the coefficients having the wrong sign. Second, demand management activities are affected by supply side characteristics z which may be correlated with x. The overall effect is indeterminate theoretically since it depends on the correlations of z and x and the strength of the effect of z on a.

The signs of the estimated coefficients on the x_{it} are in line with our expectations about their effects on demand when demand management is held constant. Increases in the proportion of the population aged 4 or less, aged 75 or more and in standardised mortality are positively associated with increases in night visits rate. Increases in the accessibility of community pharmacies are associated with a significant reduction in the demand of night visits.

6.2 Model 2: Patient demand and quality

We next test whether demand is affected by the proportion of visits made by deputies. The demand equation is

$$\ln n_{it} = a_0 + \sum_{k=1}^{K} a_k x_{itk} + a_q Q_{it} + d_1 t + d_2 t^2 + e_{it} \qquad (13)$$

where Q_{it} is the proportion of visits by deputies. The coefficient of Q_{it} is expected to be negative if patients believe that deputy visits are lower quality. Since Q_{it} is determined by GPs' decisions, its inclusion in the demand equation creates simultaneous equation bias and the demand equation cannot be estimated consistently with OLS.[8]

Table 8 compares the results when the demand equation is estimated with OLS and Instrumental Variables (IV) using exogenous supply side variables as instruments.[9] The Davidson and MacKinnon (1993, pp. 236-242) exogeneity test clearly indicates that OLS is an inconsistent estimator.

The OLS procedure gives an implausible positive and significant coefficient on the proportion of night visits made by deputies. Using IV the coefficient is still positive, though not statistically significant. Patients do not appear to care sufficiently about who makes night visits for this to affect demand.

6.3 Model 3: Demand management

When demand is affected directly by GP behaviour, though not by perceived quality, the demand function is $n = n(x, a(x, z, f)) = n^*(x, z, f)$. Since we cannot observe demand management we must estimate the reduced form demand equation $n^*(x, z, f)$ by including the supply side factors *z* and *f*. The coefficients on the demand characteristics *x* will reflect the combined effect of *x* on demand and the indirect effect of *x* via the impact of *x* on the amount of demand management. The empirical specification of the demand equation is

$$\ln n_{it} = a_0 + \sum_{k=1}^{K} a_k x_{itk} + \sum_{j=1}^{J} b_j z_{itj} + b_f f_t^g + d_1 t + d_2 t^2 + e_{it} \qquad (14)$$

Supply side variables included in the model (z_{it}) are the availability of practice nurses, the proportion of GPs solo practitioner, the proportion of GPs aged 65 or older, the number of GP per population, and the population density and the night visits fee f^g.

Table 9 presents the results of the estimated regression. To allow for comparison with the other models we report both the estimates obtained using all the 990 observations available and

[8] In terms of the theoretical model we have assumed that quality $q = -Q$ where Q is measured negatively by $Q=1-g/n$. We wish to estimate the demand function $n = D(x,q) = D(x,-Q)$ but must allow for the fact that $g = g^* = g(x,z,f)$ so that Q is correlated with the errors (unobserved components of x) in $D(.)$.

using only the 691 observations for which there is information about the proportion of night visits made by deputies. The demand side coefficients are all significant and have the expected sign.

The theoretical model suggests that the estimated coefficients on the demand factors in both Model 1 and Model 3 are biased because of unobserved demand management. Model 3 differs from Model 1 in including supply side characteristics so that the estimated Model 3 coefficients on x_{it} are subject only to the downward bias arising from the effects of x_{it} on demand management. As we noted in the discussion of Model 1 we cannot *a priori* predict the direction of bias induced by the omission of the supply side characteristics and hence the difference in the coefficients on x_{it} between the two models is also theoretically indeterminate. Although the coefficients on the x_{it} in Model 1 are on the whole somewhat smaller than those in Model 3 the differences are not statistically different, suggesting that the effect of supply variables on demand management is small.

Previous single equation single cross section models of the night visit rate (Buxton et al., 1977; Baker and Klein, 1991) have in effect adopted the reduced form specification of Model 3 and the results obtained are broadly in line with our panel data results. We expect that increases in the supply characteristics which raise the marginal cost of making night visits will lead to attempts by GPs to manage demand downwards. Conversely if the characteristics reduce marginal cost. The coefficients on the supply characteristics in Model 3 have the expected sign and are jointly statistically significant.[10] For example, we expect that single handed GPs will have higher costs of making night visits and areas with a higher proportion of such GPs will have more effort to manage demand downward so that the negative coefficient on this variable is in accordance with our predictions. Table 3 shows that the predicted effects of the GP visit fee leads GPs to change their demand management activities so that demand increases and the coefficient on the GP visit fee has the expected positive sign and is significant.

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[9] The selected instruments for the IV estimation were the proportion of GPs aged 65 or older and the proportion of GPs who had consent to use deputising services.

[10] The diagnostic statistics are satisfactory. The RESET test did not suggest misspecification. The Hausman test showed that the fixed effects model was preferred to the random effects model and the F-test on the FHSAs specific effects showed the need for a panel data model rather than pooled OLS.

6.4 Model 4: Endogenous quality and demand management

We now allow both for the possibility of physicians' demand inducement and for demand being affected by who is expected to make the visit:

$$\ln n_{it} = a_0 + \sum_{k=1}^{K} a_k x_{itk} + \sum_{j=1}^{J} b_j z_{itj} + b_f f_t^g + a_q Q_{it} + d_1 t + d_2 t^2 + e_{it} \tag{15}$$

As in the estimation of Model 2, OLS may suffer from endogenity bias due to the simultaneity of the variable measuring the proportion of night visits made by the deputising services and an IV estimator should be used. Some problem arise in finding suitable instruments as supply side variables already included in the structural equation cannot be used as instruments for the potentially endogenous quality variable. The instruments used in the IV estimation were the proportion of GPs who were dispensing doctors and the proportion of GPs who had consent to use deputising services. In the procedure to select the best set of instruments, the resulting first stage F-statistic was $F(2, 590) = 9.63$. The OID restriction test was passed comfortably.[11]

Table 10 reports the OLS and IV estimates. The F-statistics for joint inclusion of the supply side variables is highly significant, confirming that demand is affected by supply side factors. As in Model 2, the coefficient of the variable measuring the proportion of night visits made by deputising services in the OLS equation has a significant and positive sign. With IV estimation the coefficient is still positive but smaller and does not approach significance.

Comparison of the four models suggests that quality, as measured by the proportion of visits made by deputies, is not a significant factor in patient demand for night visits but that including supply variables to pick up some of the unobserved effects of demand management activities by GPs is sensible. The reduced form demand Model 3 is to be preferred to the structural Model 1.

6.5 Further evidence for demand management

We cannot observe demand management directly but our theoretical model suggests that it will be affected by the fees paid for GP and deputy visits. Because of the correlation of the changes in the GP and deputy visit fees we did not include both fees in our models of supply and demand. However, we can use the dramatic increase in GP visit fees and reduction in deputy visit fees in April 1990 to test for the effect of fees on demand management by examining the change in demand between 1989/90 and 1990/1. Reference to the comparative static predictions in Table 3 shows that practices with a lower proportion of visits by deputies are more likely to manage demand upwards after the change in fees and that practices with a higher proportion of deputy visits are more likely to respond by managing demand downwards.

Table 11 reports attempts to test this prediction. We first examined the relationship between the change in the total number of night visits between 1989/90 and 1990/1 and the proportion of practices in an area in 1989/90 which had permission to use a deputising services (d_{it-1}). We include the changes in all the supply and demand characteristics in the regression to allow for changes in the other factors affecting demand directly or indirectly through demand management. The equation is a first differenced form of the reduced form of Model 3 with an additional variable d_{it-1} intended to measure the proportion of practices which are more likely to respond to the fee changes by attempting to manage demand downwards:

$$\Delta n_{i(t,t-1)} = a_0 + gd_{t-1} + \sum_{k=1}^{K} a_k \Delta x_{ik(t,t-1)} + \sum_{j=1}^{J} b_j \Delta z_{ij(t,t-1)} + e_i \tag{16}$$

where, $\Delta x_{ik(t,t-1)}$ represents the difference in the value of variable x in the FHSA i between the financial years t (1990/91) and $t-1$ (1989/90). The change in fees does not vary across areas and its effect is picked up in the intercept

The highly significant negative coefficient on d_{it-1} provides strong support for the prediction that fee changes have led GPs either to induce demand or to cut back on attempts to reduce demand. To save space we do not report the coefficients on the intercept (highly positively significant) or the differenced variables (insignificant). We also estimated the same differenced equation replacing d_{it-1} with measures based on the proportion of visits made by deputising services in 1989/90. The results again support the argument and indicate that the relationship is non-linear.

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[11] The F-statistics in the first stage regression shows that the identifying instruments are weaker than the ones used in estimating Model 2. This fact may explain why the exogeneity test is not statistically significant (Bound et al., 1995; Staiger and Stock, 1997).

7. Conclusions

We have presented a formal but simple model of the market for night visits in general practice and shown that it is important to base empirical analysis of the market on an explicit model both to guide the estimation and to aid in the interpretation of the results. In addition to estimating the effects of socio-economic, demographic variables and the characteristics of general practices we were able to address three issues of importance to policy.

First, we found clear evidence that the GPs respond to financial incentives. The 1990/1 increase in fees for night visits by GPs and the reduction in the fee for a visit by a deputy led to large increases in the number of visits by GPs and reductions in visits by deputies. Our results support and extend earlier analyses of the fee changes by allowing in a more systematic fashion for possible confounding by changes in other factors and for the simultaneity of demand and supply.

Second, our results show that GPs actively manage the demand from their patients rather than passively meeting it. We found some evidence that exogenous increases in demand appear to lead GPs to manage demand downwards and strong signs that the 1990/1 fee changes led them either to relax efforts to restrain demand or to induce it.

Our third finding of potential policy relevance concerns the rationale for the introduction of differential fees for visits by GPs and by deputies that deputy visits are of lower quality. A recent randomised controlled trial (McKinley et al., 1997) found evidence that deputising doctors gave telephone advice less readily, take longer to visit at home and have patterns of prescribing that may be less discriminating than practice doctors (Cragg et al., 1997). Patients were also more satisfied with the out of hours care provided by practice doctors than with that provided by deputising services (though there were no significant differences in health outcomes between the two services). However, it is not clear that patients view deputy visits as lower quality. Dixon and Williams (1988) suggested that the large majority of patients were satisfied with the deputising service they received. Scott et al. (1998) found that the most important attribute of out of hours care was for patient “whether the doctor seems to listen”, followed by the location of the visit. Whether the patient was seen by a GP from their practice did not appear to matter. We found that the demand is not significantly affected by the proportion of visits made by deputies. This provides some support for those who argue that patients are not greatly concerned about who makes out of hours visits. Policy makers may be correct in viewing deputy visits as of lower quality but patients do not seem to care sufficiently to let it affect the number of night visits they demand.

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Figure 1 Effect of changes in night visits fees

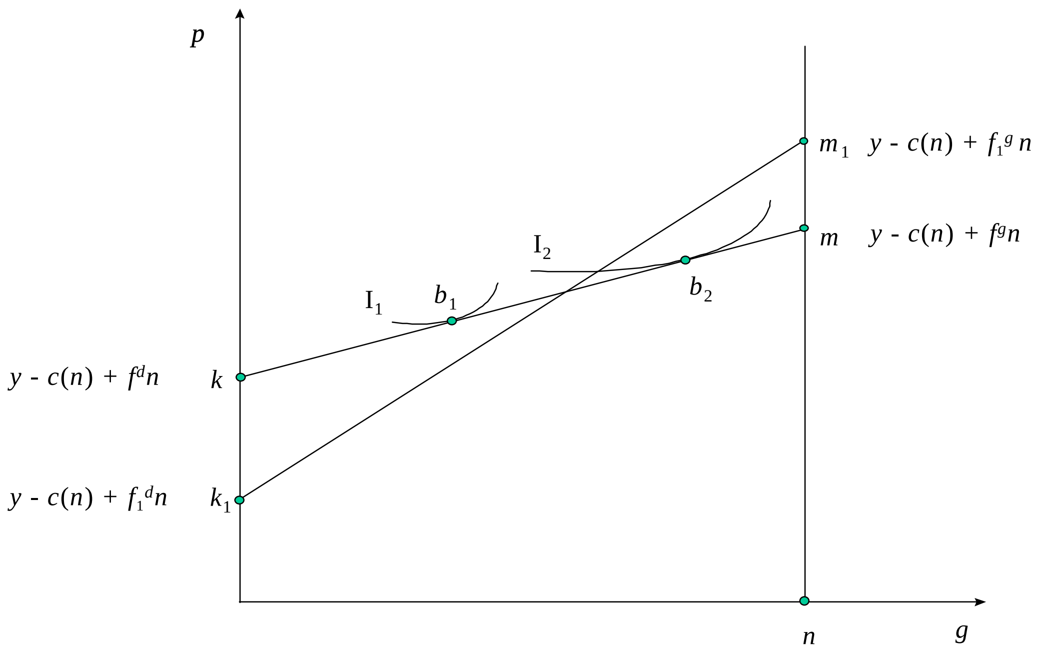

Figure 2 Effect of increase in demand

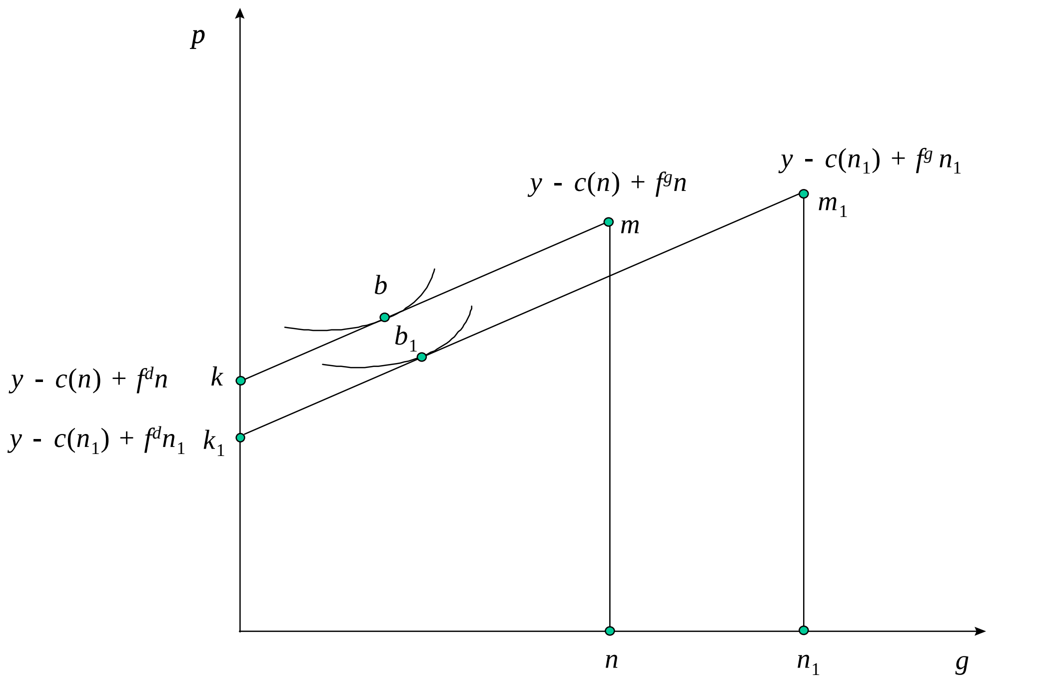

Figure 3 Effect of changes in night visits fees

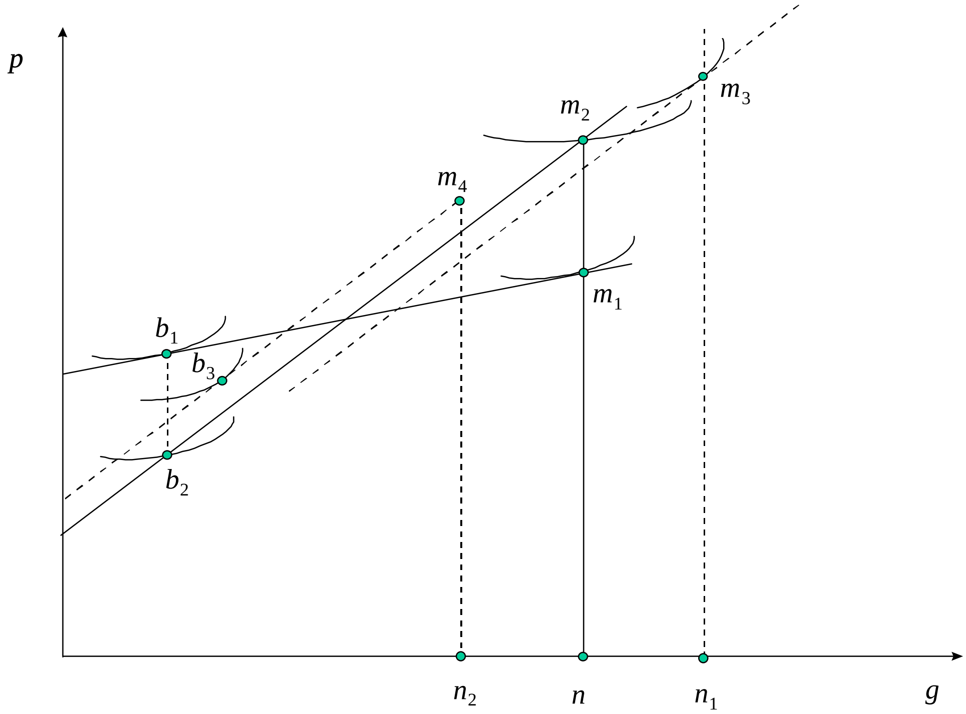

Table 1 Night visit rate per 10,000 population

Financial year	Mean	Std. Dev.	Min	Max
1967 [a]	43	-	-	-
1984-85	153.38	35.55	60.50	245.07
1985-86	166.50	40.69	61.39	291.25
1986-87	165.60	37.49	65.27	266.91
1987-88	174.50	43.04	74.11	336.00
1988-89	188.49	48.37	76.58	362.90
1989-90	196.56	49.55	88.87	366.46
1990-91	259.85	66.16	67.96	460.97
1991-92	348.80	77.55	157.37	602.30
1992-93	341.75	79.56	142.31	592.49
1993-94	376.51	81.20	109.30	646.75
1994-95	357.49	73.28	159.77	573.54

Source: Health Services Indicators (NHS Executive, 1996).
a: Source Buxton et al. (1977).

Table 2 Proportion of night visits made by deputising services

Financial year	Mean	Std. Dev.	Min	Max	Number of observation
1984-85	-	-	-	-	0
1985-86	0.471	0.341	0	0.980	84
1986-87	-	-	-	-	0
1987-88	0.456	0.340	0	0.959	73
1988-89	-	-	-	-	0
1989-90	0.486	0.336	0	0.987	84
1990-91	0.308	0.246	0	0.897	90
1991-92	0.327	0.240	0	0.806	90
1992-93	0.323	0.234	0	0.742	90
1993-94	0.349	0.228	0	0.727	90
1994-95	0.385	0.219	0	0.747	90

Source: Health Services Indicators (NHS Executive, 1996).

Table 3 Comparative static properties

	Demand	Fees		Marginal cost
	$k = x$	$k = f^{g}$	$k = f^{d}$	$k = z$, $c_{nz} > 0$
Case (i): $g = 0$				
¶g / ¶k	0	0	0	0
n_a ¶a / ¶k	–	0	+	–
	$n_x + n_a$ ¶a / ¶$x > 0$			
Case (ii): $0 < g < n$				
¶g / ¶k	0	+	–	0
n_a ¶a / ¶k	–	0	+	–
	$n_x + n_a$ ¶a / ¶$x > 0$			
Case (iii): $g = n$				
¶g / ¶k	+	+	0	–
n_a ¶a / ¶k	–	+	0	–
	$n_x + n_a$ ¶a / ¶$x > 0$			

Assumes u is additively separable in p, L, a; linear in p; no quality effects on demand ($n_a = 0$)

Table 4 Descriptive statistics

Notation	Name	Description	Mean	St.Dev	Min	Max	No. of observations
$n_{it}=(v_{it}/pop_{it})/h_t$	Night visit rate	Night visits per 10,000 population, corrected by h_t	27.188	9.255	6.796	64.675	990
x_{it}	% of children	Proportion of HA population aged 0-4	6.567	0.587	4.573	9.027	990
x_{it}	% of 75 or older	Proportion of HA population aged 75 or older	6.742	1.212	4.484	11.866	990
x_{it}	SMR	Standardised mortality rate age 5-64	102.078	12.329	65.944	136.780	990
x_{it}	Pharmacy density	Ratio between community pharmacies and HA area in '000 hectares	4.718	7.794	0.105	68.262	990
z_{it}	GPs per capita	Number of GPs per '000 population	0.526	0.039	0.432	0.697	990
z_{it}	Nurse/GP	Ratio between nurse practitioners and GPs	0.212	0.132	0	0.770	990
z_{it}	% solo GP	Proportion of GPs solo practitioner	10.956	6.878	0	37.100	990
z_{it}	% GP 65 or older	Proportion of GPs older than 65	3.367	3.107	0	22.570	990
z_{it}	Population density	Ratio between population and HA area in hectares	17.722	20.000	0.599	100.762	990
f^g_t	GP night visit fees	Fee for night visit made by GP (discounted to Jan 1995 using the purchasing power parities)	22.663	7.791	15.13	31.94	990
Q_{it}	% deputising visits	Percentage of night visits made by deputising services	0.385	0.282	0	0.987	691
g_{it}	GPs night visits per GP	Night visits made by GPs per GP, corrected by h_t	3.374	1.642	0.067	7.745	691
$n^g_{it}=(v_{it}/GP_{it})/h_t$	Night visits rate per GP	Total number of night visits per GP, corrected by h_t	5.187	1.774	1.085	12.449	990
d_{it}	% GP with deputy	Proportion of GPs who had consent to use deputising services	55.924	34.748	0	100	900
Instruments	% dispensing GP	Proportion of GPs who were dispensing doctors	11.093	14.268	0	55.215	990

v_{it}: number of night visit fees claimed in FHSA i in year t; pop_{it}: population in FHSA i in year t; GP_{it}: number of GPs in FHSA i in year t; h_t: number of hours over which visiting fees could be paid at year t.

Table 5 Estimates of the supply equation with demand side factors

Variable	Coefficients	Standard Error
GP night visit fee	0.078***	0.008
Nurse/GP	0.132	0.541
% solo GP	-0.010	0.013
% GP 65 or older	-0.039**	0.023
GPs per capita	-0.822	2.471
Population density	-0.020	0.088
% of children	0.939***	0.243
% of 75 or older	0.832***	0.199
SMR	-0.028***	0.008
Pharmacy density	0.104**	0.049
Time	-0.312***	0.086
Time^2	0.028***	0.005
Intercept	-6.524**	3.026
R^2 (within)	0.717	
Hausman test	25.69***	
RESET	10.26***	
F-test (fixed effects = 0)	12.46***	
Number of observations	691	

*** $p \leq 0.01$; ** $0.01 < p \leq 0.05$; * $0.05 < p \leq 0.1$

Dependent variable: GPs night visits per GP g_{it}

Table 6 Estimates of the supply equation with aggregate demand

	OLS		IV	
Variable	Coefficients	Standard Error	Coefficients	Standard Error
GP night visit fee	0.076***	0.007	0.058***	0.011
Nurse/GP	-0.122	0.525	-1.542**	0.817
% solo GP	-0.002	0.012	-0.011	0.016
% GP 65 or older	-0.050**	0.021	-0.075***	0.027
GPs per capita	0.608	2.345	1.381	2.877
Population density	-0.113	0.070	0.033	0.100
Night visits rate per GP	0.292***	0.035	0.882***	0.214
Time	-0.029	0.060	0.002	0.074
Time^2	0.004	0.004	-0.010	0.006
Intercept	1.591	1.865	-5.242**	2.727
R^2 (within)	0.732		0.784	
Hausman test	28.94***			
RESET	2.92**			
F-test (fixed effects = 0)	14.28***		9.52***	
Exogeneity test			0.613***	0.177
OID restrictions test $\chi^2(2)$			0.695	
1st stage F-test			7.94***	
Number of observations	691		691	

*** $p \leq 0.01$; ** $0.01 < p \leq 0.05$; * $0.05 < p \leq 0.1$

Dependent variable: $\ln(g_{it})$

The instruments used in the IV estimation are the proportions of the population aged 4 or less, aged 75 or more, and pharmacy density.

Table 7 Estimates of the demand equation: Model 1 - exogenous demand

Variable	Coefficients	Standard Error	Coefficients	Standard Error
% of children	0.112***	0.031	0.202***	0.049
% of 75 or older	0.164***	0.024	0.175***	0.037
SMR	0.007***	0.001	0.008***	0.002
Pharmacy density	-0.018***	0.005	-0.023***	0.009
Time	-0.008	0.009	-0.023	0.016
Time^2	0.005***	0.001	0.006***	0.001
Intercept	0.535	0.275	-0.108	0.415
R^2 (within)	0.810		0.750	
Hausman test	25.32***		13.24**	
RESET	2.40*		0.70	
F-test (fixed effects = 0)	14.23***		8.62***	
Number of observations	990		691	

*** $p \leq 0.01$; ** $0.01 < p \leq 0.05$; * $0.05 < p \leq 0.1$

Dependent variable: $\ln(n_{it})$

Table 8 Estimates of the demand equation: Model 2 - endogenous quality

	OLS		IV	
Variable	Coefficients	Standard Error	Coefficients	Standard Error
% of children	0.283***	0.047	0.208***	0.059
% of 75 or older	0.190***	0.035	0.176***	0.038
SMR	0.004**	0.002	0.008***	0.002
Pharmacy density	-0.024***	0.008	-0.023***	0.009
% deputising visits	0.342***	0.042	0.025	0.143
Time	-0.022	0.015	-0.023	0.016
Time^2	0.006***	0.001	0.006***	0.001
Intercept	-0.439	0.396	0.314	0.447
R^2 (within)	0.775		0.836	
Hausman test	24.99***			
RESET	0.43			
F-test (fixed effects = 0)	8.52***		8.65***	
Exogeneity test			-0.350**	0.143
OID restrictions test $\chi^2(1)$			0.04	
1st stage F-test			30.31***	
Number of observations	691		691	

*** $p \leq 0.01$; ** $0.01 < p \leq 0.05$; * $0.05 < p \leq 0.1$

The instruments used in the IV estimation are the proportion of GP aged 65 or older and the proportion of GP who had consent to use deputising services.

Dependent variable: $\ln(n_{it})$

Table 9 Estimates of the demand equation: Model 3 - demand management

Variable	Coefficients	Standard Error	Coefficients	Standard Error
% of children	0.089***	0.032	0.165***	0.050
% of 75 or older	0.132***	0.027	0.156***	0.041
SMR	0.008***	0.001	0.008***	0.002
Pharmacy density	-0.022***	0.006	-0.025**	0.010
GP per capita	0.838**	0.354	1.408***	0.504
GP night visit fee	0.005***	0.001	0.005***	0.002
Nurse/GP	0.214**	0.090	0.293***	0.110
% solo GP	-0.004**	0.002	-0.003	0.003
% GP 65 or older	0.001	0.003	-0.002	0.005
Population density	0.005	0.011	0.025	0.018
Time	-0.016*	0.010	-0.056***	0.018
$Time^2$	0.005***	0.001	0.007***	0.001
Intercept	0.328	0.411	-0.912	0.617
R^2 (within)	0.821		0.767	
Hausman test	60.01***		31.52***	
RESET	1.41		1.06	
F-test (fixed effects = 0)	13.72***		8.19***	
F (all supply-side variables = 0)	8.83***		7.25***	
F-test (*GP night visit fee, GP per capita* = 0)	9.63***		8.81***	
Number of observations	990		691	

*** $p \leq 0.01$; ** $0.01 < p \leq 0.05$; * $0.05 < p \leq 0.1$

Dependent variable: $\ln(n_{it})$

Table 10 Estimates of the demand equation: Model 4 - endogenous quality and demand management

	OLS		IV	
Variable	Coefficients	Standard Error	Coefficients	Standard Error
% of children	0.239***	0.046	0.222***	0.060
% of 75 or older	0.156***	0.037	0.156***	0.037
SMR	0.004**	0.002	0.005*	0.003
Pharmacy density	-0.021**	0.009	-0.022**	0.009
GP per capita	0.986**	0.462	1.083**	0.514
GP night visit fee	0.010***	0.001	0.009***	0.003
Nurse/GP	0.199**	0.101	0.221*	0.113
% solo GP	-0.002	0.002	-0.002	0.003
% GP 65 or older	-0.008*	0.004	-0.007	0.005
Population density	0.024	0.016	0.024	0.016
% deputising visits	0.462***	0.042	0.355	0.244
Time	-0.059***	0.016	-0.058***	0.016
Time^2	0.007***	0.001	0.007***	0.001
Intercept	-0.953*	0.563	-0.323	0.479
R^2 (within)	0.806			0.869
Hausman test	41.92***			
RESET	2.54*			
F-test (fixed effects = 0)	7.66***		7.55***	
F (all supply-side variables = 0)	15.65***		8.06***	
F-test (*GP night visit fee*, *GP per capita* = 0)	25.65***		10.13***	
Exogeneity test			-0.110	0.247
OID restrictions test $\chi^2(1)$			0.35	
1st stage F-test			9.17***	
Number of observations	691		691	

*** $p \leq 0.01$; ** $0.01 < p \leq 0.05$; * $0.05 < p \leq 0.1$

The instruments used in the IV estimation are the proportion of GPs who were dispensing doctors and the proportion of GPs who had consent to use deputising services.

Dependent variable: $\ln(n_{it})$

Table 11 Evidence for demand management

Variable	Coefficient from multiple regression[a]	Standard Error
% of GPs in 1989/90 with consent to use deputies	-35.276***	12.320
% of visits by deputies in 1989/90	-1704.65	1509
% of visits by deputies in 1989/90	8465.78*	4540
(% of visits by deputies in 1989/90)^2	-11674.12**	4934
F-test of joint significance [F(2,72)]	3.48**	
Dummy = 1 if $q_{8990} > 50\%$, 0 otherwise	-1541.03	940
Dummy = 1 if $q_{8990} > 70\%$, 0 otherwise	-2069.21**	1005
Dummy = 1 if $q_{8990} > 80\%$, 0 otherwise	-2462.99**	1021

*** indicates $p \leq 0.01$; ** indicates $0.01 < p \leq 0.05$; * indicates $0.05 < p \leq 0.1$

[a] regressions also included changes in all supply side (Δz_{it}) and demand side (Δx_{it})characteristics

q_{8990} = % of visits by deputies in 1989/90;

Dependent variable: Δ night visits rate = $n_{i1990/1} - n_{i1989/90}$.