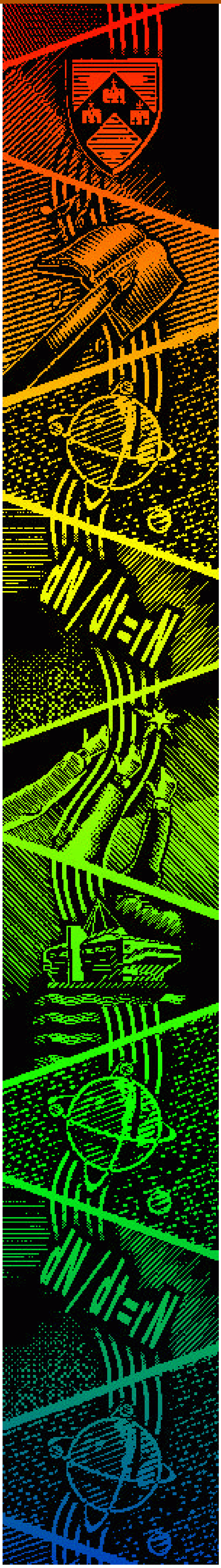

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Efficiency and Administrative Costs in Primary Care

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Abstract

We construct a simple model of the determinants of administrative managerial effort and apply it explain the doubling of the cost of administering primary care in England in real terms between 1989/90 and 1994/5 following the introduction of the internal market. We find that the main cost driver was the number of GPs, that there are economies of scale but not economies of scope in administration, and that fundholding appeared to increase administrative costs. Most the increase in administrative cost over the period could not be explained by the change in the cost drivers or fundholding, suggesting that the recent abolition of fundholding may do little to reduce primary care administrative costs.

Keywords: primary care; administrative costs; efficiency measurement; performance indicators.

JEL codes: I18, I11, L31

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1. Introduction

This paper estimates a cost function for primary care administration using a panel of data for Family Health Service Authorities (FHSAs) in England. It makes a number of methodological and substantive contributions.

First, we set out a simple model of the determinants of administrative costs. We use the model to examine the implications of endogenous managerial effort for what is meant by inefficiency and for the estimation of the cost function. The econometric approach to the estimation of the cost administrative cost function which we use has been advocated in previous discussions of the measurement of efficiency (Schmidt and Sicklets, 1984). Our modelling approach is therefore of wider interest for the estimation of efficiency in health care. In particular it complements the debate in the Symposium on Frontier Estimation in the *Journal of Health Economics*[1] which focused on alternative methods for estimating efficiency, rather than on the welfare implications of the estimates.

Second, we examine how far the doubling of administrative expenditure between 1989/90 and 1994/5 is due to shifts in the cost function and changes in administrative tasks. Our analysis is relevant to the debate about the effect of the introduction of the internal market in the British National Health Services (NHS) and the changes to the contract between the NHS and the general practitioners who act as gatekeepers to the system. One of the justifications for the current sweeping changes in the organisation of the NHS is that the introduction of the internal market and the changes to the general practitioners contract from 1989/90 onward led, amongst other things, to an increase in administration costs (Department of Health, 1997). By estimating an administrative cost function for primary care services we provide some evidence of the possible effect of the internal market, in particular of the spread of fundholding practices, on administrative costs in primary care.

Third, the cost function enables us to examine the extent of economies of scale and scope in primary care administration. The recent reorganisation of the NHS has led to a devolution of some administrative responsibilities for primary care from health authorities to more numerous

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[1] See the papers in the *Journal of Health Economics*, 13(3), 1994, pages 255-346.

lower level units (Primary Care Groups). It also expected that the reforms will lead health authorities to merge (Department of Health, 1997).

Fourth, the estimated cost function is relevant for the current policy focus on explicit measurement of performance and initiatives to reduce administrative cost (Department of Health, 1997; NHS Executive, 1998). We use the estimated cost function to examine differences in administrative expenditure across health authorities and the potential gains achievable if such differences can be attributed to differences in efficiency.

Section 2 presents a simple model of the determinants of administrative costs and discusses whether differences in costs imply differences in efficiency. Section 3 gives the institutional background and outlines the data. Section 4 describes the regression model and estimation methods. Section 5 presents and discusses the results. Section 6 concludes.

2. Modelling inefficiency

In this section we set out a simple model of the determinants of administrative costs. We suppose that endogenous managerial effort affects administrative cost so that what is usually measured as exogenous inefficiency is in fact endogenous. This has implications both for the welfare interpretation of the empirical results and for the estimation of the administrative cost function. Our approach is similar to Gaynor and Pauly (1990) in that we allow for endogenous effort but do so in a rather different institutional setting with different property rights.

2.1 Managerial effort and administrative costs

The manager in the primary health care authority controls a vector of administrative inputs $L_1,\ldots,L_n$ (clerks, office space, computers, etc.) with parametric input prices $w_1,..,w_n$. The manager receives a salary w_0. Defining $L = (L_1,\ldots,L_n)$ total administrative expenditure is $w_0 + wL$. The authority's main task is administering payments to primary care practitioners and service providers (GPs, dentists, opticians, pharmacies). (We give a fuller account of the role of the health authority in section 4).

There is an administrative technology defined by[2]

$$g(a, q, L; x) \geq 0 \qquad g_a > 0,\ g_q < 0,\ g_L < 0,\ g_x < 0, \tag{1}$$

where a is the effort of the manager, q is a vector of endogenous variables which can be influenced by health authority managers, and x is a vector of exogenous variables.

To fix ideas we think of q as measuring some aspects of the quality of care provided in the authority, for example the proportion of women aged 25-64 who receive a cervical smear. Managers can increase this proportion by providing information and advice to general practitioners. Increases in the proportion can trigger additional payments to GPs and hence additional processing by the FSHA, so that an increase in q may be costly.

The components of x include the primary care workers (GPs, dentists, opticians, etc.) in the authority: the more such workers the greater the administrative services required in connection with payments, budget setting and monitoring. x also includes population characteristics (such as morbidity) and characteristics of the authority, such as its area and transport facilities. We assume for the purposes of this section that the primary care work force to be serviced by the authority is exogenous.[3] We test for the endogeneity of the quality and primary care worker variables in section 5.

Suppose that the managerial utility function is [4]

$$m = m(a, r; x, w) = b_0 b(q; x) - b_1 wL - b_2 a^2 + b_3 w_0 \tag{2}$$

where $b_i > 0$, $i = 0,...,3$. Managers prefer higher salaries and dislike effort. In equation (2), $b(q;x)$ is the net social benefit from the health care provided with given numbers of primary care staff supplying primary care services of quality q to a given population. Note that b is net of the costs of GPs, other primary care staff, pharmaceuticals prescribed etc. Managers are concerned both about the health of the population and the costs of providing primary care. This may be because of altruism or because they care about the judgement of their professional

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[2] g_q, g_L, g_x are (vectors of) partial derivatives with respect to the components of q,L,y. We define the components of x so that increases in x tighten the technology constraint.

[3] The remuneration of primary care staff was nationally negotiated.

[4] Many of our points would be valid with a more general function but this simple form enables sharper conclusions to be drawn.

expertise which is based on the performance of their authority and its administrative expenditure.

If we define a as effective effort, the parameter b_2 can capture the tastes and the productivity of the manager. For example, suppose that managers care about the number of hours they work and that h hours input by a manager of calibre j yields effective effort $a = hj$. Then b'_2h^2 is the cost of h hours and $b_2a^2 = (b'_2/j^2)a^2$ is the cost of effective effort where b_2 reflects both the manager's preferences and his productivity.

We examine the decisions by the manager in three stages.[5] At stage 1, for given $a,q,x,$ and w, the manager's chooses L subject to the technological constraint $g(a,q,L;x) \geq 0$. Even if managerial salary w_0 is an increasing function of administrative expenditure we assume that the manager's preference parameters and the relationship between salary and administrative expenditures are such that, for given $a,q,x,$ and w, managerial utility is a monotonically decreasing function of administrative expenditure.[6] Hence the manager's decision is equivalent to choosing L to minimise the cost of the non-managerial inputs. The preference parameters b have no effect on the stage 1 decision since they merely scale the input prices. The optimal input vector $L(a,q;x,w)$ gives the administrative cost function conditional on effort:

$$C = w_0 + wL(a,q;x,w) = C(a,q;x,w), \qquad C_a < 0, C_q > 0, C_x > 0, C_a < 0, C_w = L \quad (3)$$

The manager's stage 2 decision is to choose managerial effort, for given q, to maximise

$$m = b_0 b(q;x) - b_1 C(a,q;x,w) - b_2 a^2 + (b_3 + b_1)w_0 \quad (4)$$

The first order condition is

$$b_1 C_a(a,q;x,w) - 2b_2 a = 0 \quad (5)$$

yielding the optimal effort decision $a^o = a^o(q;x,w,b)$ and the administrative cost function

[5] We assume that b is concave in q and that the feasible set defined by the administrative production technology $g(.)$ is convex so that the optimisation problems at each stage are well behaved and first order conditions identify unique global solutions.
[6] The effect on managerial utility of an increase in non-managerial administrative expenditure is $-b_1 + b_3w_0'(wL)$ so that provided that $w_0'(wL)$ is sufficiently small, utility declines with expenditure.

$$C^o = C(a^o(q;x,w,b),q;x,w) = C^o(q;x,w,b) \tag{6}$$

The comparative static properties are straightforward. *Effort is increasing in* b_1 *and decreasing in* b_2. *Increases in quality q and the exogenous variables x increase effort if and only if they increase the productivity of effort* ($C_{aq} < 0$, $C_{ax} < 0$).

Unsurprisingly, managers supply more effort, at a given q, if they place greater weight on the administration cost relative to their effort cost. More productive managers, who therefore have smaller marginal costs of effective effort, also supply a greater amount of effective effort, though they may put in fewer nominal hours. Although increases in q or x increase administration costs, their effect on effort depends on whether they increase the cost by reducing the effects of additional effort. Alternatively, since $C_{aq} = C_{qa}$, $C_{ax} = C_{xa}$ effort increases with these variables if it reduces their marginal cost.[7]

The stage three decision is to choose quality, taking account of its effect on the net benefits b and on administrative costs C^o. The first order condition is, remembering that a^o is chosen optimally,

$$b_0 b_q - b_1 C_q - (b_1 C_a + 2b_2 a^o)a_q^o = b_0 b_p(q,x) - b_1 C_q(a^o, q; x, w) = 0 \tag{7}$$

The optimal $q^{oo} = q^{oo}(x,w,b)$ and $a^{oo} = a^o(q^{oo};x,w,b) = a^{oo}(x,w,b)$ give the observed level of administrative costs in the authority

$$C^{oo} = C(a^{oo}(x,w,b), q^{oo}(x,w,b), x, w) = C^{oo}(x,w,b) \tag{8}$$

Using the first order conditions (7) and (5) we see that *quality is increasing in* b_0 but that the effects of the other preference parameters depend on C_{aq} because they will also induce changes in effort, and therefore in the marginal cost of quality. Thus

$$\operatorname{sgn}\frac{\partial q^{oo}}{\partial b_1} = \operatorname{sgn}\left[-C_q - b_1 C_{aq} a_{b_1}^o\right] \tag{9}$$

$$\operatorname{sgn}\frac{\partial q^{oo}}{\partial b_2} = \operatorname{sgn}\left[-b_1 C_{aq} a_{b_2}^o\right] \tag{10}$$

Since $a_{b_1}^{o} > 0$ and $a_{b_2}^{o} < 0$ we see that *if additional effort reduces the marginal cost of quality then quality decreases with* b_2 *but may increase or fall with* b_1. Increases in the effort parameter b_2 reduce effort and this increases the marginal cost of quality, thereby reducing its optimal level. However, although increases in the value of cost reductions b_1 increase effort and reduce the marginal cost of quality, this effect is counteracted by the fact that increases in quality are costly and a greater weight is attached to such increases.

2.2 Policy implications

In section 5 we estimate an administrative cost function from data on administrative expenditure and its determinants. If their preference parameters differ, managers will supply different amounts of effort, conditional on the other determinants of administrative expenditure. Those with lower effort levels will have higher administrative costs. What is the policy significance of such cost differences? Suppose that the welfare function is

$$S = g_0 b(q;x) - g_1 wL - g_2 a^2 \tag{11}$$

Welfare is identical to the manager's objective function except for the possibly different weights on the net benefits, the costs of the non-managerial administrative inputs and the manager's effort costs. We assume that the input prices *w* measure the social opportunity costs of the inputs and that the social cost of managerial effort is $g_2 a^2$. The salary of the manager is a transfer payment.

The divergence between the socially optimal decisions and those taken by the manager arises from the differences in the welfare and managerial objectives. Given the simple form of the manager's utility function and the welfare function, what matters are the relative weights assigned to net benefits *b*, administrative costs *C* and managerial effort *a*. These weights depend on managerial preferences and on property rights.

Without loss of generality, we can set $g_2 = b_2$, so that the welfare function takes full account of the manager's private effort cost.[8] Although distributional concerns about the relative merits

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[7] Equality of cross partials of the cost function requires that the technology is smooth enough in the sense of *g* having continuous second derivatives.

[8] With more than one health authority we must allow for the fact that there will possibly be different vectors $(b_0^i, b_1^i, b_2^i, b_3^i)$ of managerial preference parameters across the health authorities. There is no reason why the

of patients, providers, taxpayers and administrators are important in health care, they are picked up in the weights on net benefits and administrative costs.

It seems plausible that $g_1 > b_1 > 0$. Managers may care about administrative costs for a variety of reasons which are captured in b_1. Professional pride in a reputation for "running a tight ship" tends to increase b_1. Conversely managers who feel that their prestige and status are increased if they have more subordinates will tend to have smaller b_1. Although administrative costs must be funded from taxation and managers are taxpayers, the effect of a reduction in administrative costs on the tax bill of any individual taxpayer is negligible. The welfare function counts such effects in full since they are summed over all the taxpayers. We assume that on balance managers prefer smaller administrative expenditure but that they do not properly internalise the full social effects of increased administrative expenditure.

It is also plausible that $g_0 > b_0 > 0$, so that managers are semi-altruistic as regards the social benefits and costs of the health care outputs produced in their authority. However, the weight they place on them relative to their effort costs is smaller than the social weight.

Welfare is maximised in three stages. At stage 1, expenditure on the administrative inputs L is minimised for given levels of managerial effort and q. Since the manager's utility is decreasing in administrative cost, the manager chooses the socially optimal mix of administrative inputs for a given level of managerial effort and quality. The welfare function can be therefore be written as

$$S = S(a,q;x,w) = g_0 b - g_1 wL - g_2 a^2 = g_0 b(q;x) - g_1 C(a,q;x,w) - g_2 a^2 + g_1 w_0 \qquad (12)$$

Since the welfare function differs from the managerial utility function only in the weights, the socially optimal stage 2 effort is $a^* = a^o(q;x,w,g)$ and the socially optimal stage 3 decision on quality is $q^{**} = q^{oo}(x,w,g)$. The maximised social welfare is

$$S^{**} = S(a^{**},q^{**};x,w) = g_0 b(q^{**};x) - g_1 C(a^{**},q^{**};x,w) - g_2 (a^{**})^2 + g_1 w_0 = S^{**}(x,w,g) \qquad (13)$$

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social preference parameter on administration costs should differ across authorities. It could be argued that the parameter on net benefits could vary with the area to reflect say greater value being placed on benefits accruing in poorer areas. There seem to be no such distributional considerations which would suggest that managerial preferences as regards the cost of effort should be respected in some areas but not in others. Hence we would have g_0^i possibly varying across areas, $g_1^i = g_1, \forall i$ and $g_2^i = b_2^i, \forall i$

where $a^{**} = a^{oo}(x,w,g) = a^{o}(q;^{**} x,w,g)$.

The cost function $C^o(q;x,w,g) = C(a^o(q;x,w,g),q;x,w,g)$ shows the administrative costs for a given quality when the administrative inputs and managerial effort are chosen to maximise welfare. Call $C^o(q;x,w,g)$ the *first best cost function* and suppose for the moment that $C^o(q;x,w,g)$ is known. Given the assumptions about managerial and social preference weights, it is obvious from the first order condition on effort choice (5) that the manager chooses too little effort.[9] Consequently the authority will lie above the first best function:

$$C^o(q;x,w,b) - C^o(q;x,w,g) > 0 \tag{14}$$

However, comparison of the welfare and managerial utility maximising decisions shows that some care is required in drawing welfare implications from the fact that an authority lies above the first best cost function. The welfare loss

$$\begin{aligned} &S(a^{**},q^{**};x,w) - S(a^{oo},q^{oo};x,w) \\ &= S(a^{oo}(x,w,g),q^{oo}(x,w,g);x,w) - S(a^{oo}(x,w,b),q^{oo}(x,w,b);x,w) \end{aligned} \tag{15}$$

arises because the manager is incompletely altruistic: she chooses the wrong effort and endogenous quality. The excess administrative expenditure (14) fails to reflect the welfare loss for two reasons. First, it does not allow for the fact that quality as well as effort diverge from the social optimum cost. If q is in fact endogenous in the sense that it is under the control of the manager, we have to take account of the first type of error in using (14) as a measure of (15). We test for endogeneity of quality in the cost function in section 5.

Second, even if quality is exogenous, so that only managerial effort is at issue, (14) ignores the cost of the manager's effort. Since $a^o(q;x,w,g)$ minimises $C(a,q;x,w) + g_2a^2/g_1$ the welfare loss at given quality is proportional to[10]

$$\begin{aligned} &[C^o(q;x,w,b) - C^o(q;x,w,g)] + (g_2/g_1)[a^o(q;x,w,b)^2 - a^o(q;x,w,g)^2] \\ &< [C^o(q;x,w,b) - C^o(q;x,w,g)] \end{aligned} \tag{16}$$

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[9] The effect of the preference parameter on effort is $¶a^o/¶b_1 = - C_a/(b_1C_{aa}+b_2) > 0$ and we have assumed that $b_1 < g_1$.

The importance of the over-estimation of the welfare loss depends on the relative magnitudes of the difference between managerial effort costs at the private and social optimum and the difference between administrative costs at these points. It is plausible that the difference between the true welfare loss (the left hand side of (16)) and the measured difference in administrative costs (the right hand side) is not large. Managerial effort cost is likely to be negligible compared with the cost of the other administrative inputs, so that the difference between the cost of privately and socially optimal managerial effort is also negligible and so the difference in administrative costs in (14) may be a reasonable measure of the welfare loss from the manager's suboptimal effort.

Low managerial effort leads to a welfare loss relative to the first best situation achievable if the regulator can observe and control managerial effort. Managerial effort is also likely to be second best inefficient in the sense that managers can be made better off and administrative cost reduced even when managerial effort and preferences are not observed. Since administrative cost is observable it is possible to design an incentive scheme which makes the manager better off and reduces administrative costs.[11] The scheme would be equivalent to increasing the manager's preference parameter b_1, so that she supplies more effort and reduces administrative expenditure.

In general managerial incentive schemes will not lead to a first best effort level. Not only are the manager's preferences not fully known, account would also have to be taken of the unobserved random factors affecting costs and of managerial risk aversion. Further, if we also allow for the fact that some aspects of the quality of care may be both endogenous and observed with error, the optimal second best scheme may be very low power to avoid giving managers too large an incentive to reduce cost by reducing quality (Holmstrom and Milgrom, 1991) .

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[10] Although the manager's salary cost w_0 is not a social cost of producing administrative services (the social cost of managerial effort is g_2a^2) and is included in $C = w_0 + wL$, it drops out of the difference between $C^o(q;x,w,b)$ and $C^o(q;x,w,g)$, which is just the difference between the costs of vectors of non-managerial inputs.

[11] For example, with $w_0 = k_0 - k_1C$ ($\kappa_1 > 0$), the marginal value of additional effort to the manager is $-[b_1 + (b_1 + b_3)k_1]C_a - 2b_2a$, so that the manager is induced to supply additional effort and k_0 can be set to ensure he is better off. Since the marginal social value of w_0 is zero suitable choice of the incentive scheme parameters also increases welfare.

The administrative cost function which can be estimated is not the first best cost function $C^o(q;x,w,g)$ but the function corresponding to the effort level of the area with the greatest effort level: $C^o(q;x,w,b^{\max})$ where $b^{\max} < g_1$ is the maximum value of the preference parameter b_1 across the areas. Since even the manager with the highest marginal valuation of administration cost reductions undervalues cost reductions, comparison of the administration cost $C^o(q^i;x^i,w^i,b^i)$ in area i with the estimated function $C^o(q^i;x^i,w^i,b^{\max})$ will underestimate the administrative cost reduction which could be achieved by supplying the first best amount of effort.

However, even in these circumstances there is value in estimating the cost function. The differences in costs between areas can be used to identify those where there is apparently poor performance which merits further more detailed investigation. The differences in costs which remain after such investigation provide some guidance as the potential welfare gains from introducing incentive schemes and other mechanisms for improving performance.

2.3 Implications for estimation results

The second reason for introducing a simple formal model of managerial decisions is to guide the estimation of the cost function and the interpretation of the results. We have assumed that additional effort by managers can reduce expenditure on inputs required to administer the primary care system. Assume for the moment that managerial effort is the only endogenous variable in the cost function. Effort will be a function of all the other variables in the cost function and managerial preferences. To illustrate the implications, suppose that, after suitable transformation, the true cost function in area i at time t is

$$c_{it} = d_1 x_{1it} + d_2 x_{2it} + d_3 a_{it} + e_{it} \qquad (17)$$

where c_{it} is the (transformed) administrative cost, x_{1it} is an observable exogenous variable and x_{2it} is also exogenous but unobserved. e_{it} is a zero mean i.i.d error term reflecting unobservable exogenous factors which do not influence managerial effort and are uncorrelated with the x_{1it}, x_{2it}. Assume that the unobserved variable is correlated with the observed:

$$x_{2it} = f_{0i} + f_1 x_{1it} + r_{it} \qquad (18)$$

and r_{it} a zero mean i.i.d. error. Managerial effort is

$$a_{it} = a_{0i} + a_1 x_{1it} + a_2 x_{2it} + v_{it} \qquad (19)$$

where a_{0i} reflects authority specific factors and v_{it} is a zero mean i.i.d. error term. Because the unobserved managerial effort and the unobserved x_{2it} have area specific components OLS would yield biased estimates and panel data techniques should be used. Random effects estimation requires that the area effects are not correlated with x_{1it} (Baltagi, 1995). But the omitted x_{2it} are correlated with x_{1it} by assumption and the omitted managerial effort variable is correlated with x_{1it} (directly and indirectly via x_{2it}) from the manager's optimisation problem. Thus the endogeneity of managerial effort indicates that we should use fixed effects procedures to estimate the cost function.

The coefficients in the estimated cost equation

$$c_{it} = d_0 + \sum_{j=2} d_{0j} D_j + d_1 x_{1it} \qquad (20)$$

where the D_j are area dummies, satisfy

$$\text{plim } d_0 = d_0 + (d_2 + d_3 a_2) f_0 \qquad (21)$$

$$\text{plim } d_{0i} = (d_2 + d_3 a_2) f_{0i} + d_3 a_{0i} \qquad (22)$$

$$\text{plim } d_1 = d_1 + (d_2 + d_3 a_2) f_1 + d_3 a_1 \qquad (23)$$

It has been suggested (Schmidt and Sickles, 1984; Skinner, 1994) that the estimated area specific effects d_{0i} can be used to make inferences about the relative efficiency of the areas. We argued in the previous section that a better interpretation of the differences in cost remaining after allowing for the non-effort variables is as an indication of the possible scope for welfare improvements from changing incentives.

As the first term in (22) makes clear, the estimated area specific effects can also reflect the impact of unobserved variables (x_{2it}) (Dor, 1994; Newhouse, 1994). The area effects measure differences in managerial effort and therefore potential welfare gains only if the unobserved variables (a) do not vary systematically across areas ($f_{0i} = 0, \forall i$) or (b) do not affect the cost function, either directly ($d_2 = 0$) or indirectly through managerial effort ($a_2 = 0$).

The endogeneity of managerial effort also poses potential problems for the interpretation of the coefficients on the included exogenous variables, as (23) shows. Even if the omitted exogenous variable is uncorrelated with the included one, the coefficient on x_{1it} will be biased because it also picks up the unobserved influence of managerial effort on administrative costs.

From the discussion of the comparative statics of managerial effort in section 2.1 we know that managerial effort increases with an exogenous variable if and only if increases in effort reduce marginal cost of the variable. We have defined all the arguments in C except a to have a positive marginal cost and the cost function we actually estimate in section 5 is multiplicatively separable ($C = f(x)u(a)$) between effort and its other arguments. This implies, in terms of (23), that $d_1 > 0$, but that $d_3 < 0$ and $a_1 > 0$, so that the estimated coefficient on x_1 might even have the wrong sign if the direct effect of x_1 on costs is more than offset by the cost reduction caused by the induced increase in effort. However, we can show that the net effect of an increase in the non-effort arguments is to increase costs provided only that ln $u(a)$ convex.[12] This is satisfied by $u(a) = \exp(-a)$ which is implicitly assumed in attempts to estimate "efficiency" in terms of the residuals or area specific dummies with logarithmic cost functions. Thus endogeneity of effort will not lead to incorrect signs on the coefficients of exogenous variables, though it may bias them towards zero.

These conclusions about the interpretation of the coefficients on the observed variables and the area dummy variables are reinforced when account is taken of omitted variable bias. This can arise in the usual way if omitted variables are correlated with included variables. It can also arise from endogeneity. We can test and allow for endogenous included variables but if there are unobserved endogenous variables they will in general be functions of the exogenous variables, both observed and unobserved and will impart bias to the coefficients on the observed variables.

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[12] The cost function is $C = f(x)u(a)$ where $u = e^U$ and $U' < 0$, $U'' > 0$. Differentiate the cost function totally with respect to one of the non-effort arguments x of the cost function

$$\frac{dC}{dx} = C_x + C_a a_x = C_x - C_a \frac{b_1 C_{ax}}{b_1 C_{aa} + 2b_2},$$

Multiplying through by the denominator in the second term, using the first order condition to substitute for $2b_2$, and using the assumed functional form gives

$$\text{sgn}(dC/dx) = \text{sgn}\left[ff_x (uu'' - u'u' - uu'/a) \right]$$

Since $f_x > 0$, $u' < 0$, dC/dx is positive if ln u is weakly convex, which is equivalent to U being weakly convex.

We interpret the simple model of administrative costs as warning that care is required in drawing strong conclusions from empirical estimates of cost functions and of inefficiency. Such warnings always in order given the imperfections of health service data sets. A formal model at least cautions us as the likely sources of bias and possibly their directions.

3. Data and institutional background

During the period of our analysis (1989/90 to 1994/5[13]) primary care in England was administrated by 90 Family Health Service Authorities (FHSAs) covering geographically defined populations of about 500,000.[14] Prior to April 1990 FHSAs were mainly responsible for administering payments to general practitioners, practice nurses, dentists, opticians, and pharmacies providing primary care services. The new GP contract in 1990 expanded the tasks of FHSAs and increased the range of activities for which GPs could claim payment. FHSAs also increased their monitoring role and were expected to improve the quality of primary care by feeding back information to GPs and encouraging peer review. From April 1991 practices were permitted to hold budgets to spend on certain types of secondary care and on pharmaceuticals. The budgets were negotiated with FHSAs and administered by them.

The data are annual observations from the Health Service Indicators (HSI), a database collected by the NHS Executive (NHS Executive, several years). Table 1 contains definitions and descriptive statistics of the variables used in the analysis. The dependent variable is the total revenue expenditure on FHSAs administration in £ 000' in current prices.[15]

The variables we consider to be the main drivers of FHSA administrative expenditure are the numbers of general practitioners, practice nurses, ophthalmic medical practitioners, dentists and community pharmacies in the FHSA.

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[13] These are financial years running from April 1 to March 31.

[14] Before April 1990 FHSAs were called Family Practitioner Committees. In April 1996 FHSAs were reorganised into 100 new Health Authorities which combined responsibility for secondary and primary care.

[15] Expenditure on administration includes: authority member's remuneration; honoraria, fees etc for FHSA advisers; medical audit teams fees etc; other salaries and wages; computer supplies and services; other supplies and services; establishment expenses; bank charges; hire purchase and lease charges; transport and moveable plant; premises and fixed plant; agency services; recharges from other FHSAs/HAs and NHS Trusts; auditors remuneration; miscellaneous.

FHSA accounts do not provide information on prices of administrative inputs. We therefore used the New Earnings Survey (Department of Employment, several years) to construct an index of administrative labour input prices as the regional average gross weekly earnings for full-time non-manual workers on adult rates in public administration.[16] To allow for other sources of variation in input prices we also included dummies variables for three types of area, relative to inner London: outer London, metropolitan areas (roughly other large city areas) and shire counties (non urban areas).

The obvious major change in the organisation of primary care in the period under consideration was the introduction of general practitioners fundholding in April 1991. Fundholding practices held budgets to cover the costs of referring their patients for certain categories of non emergency secondary care. The scheme increased FHSAs' administrative burden as they had to negotiate the budget for fundholders each year, to monitor financial outcomes and to check on the use to which fundholders put any budget surplus. We measure the burden of fundholding in a year as the proportion of practices which were fundholders in the following year to allow for the fact that fundholder budgets were negotiated in the previous year.

The quality of the primary health care provided in the FHSAs is proxied by the success of cervical cytology screening. Before the 1st April 1990 GPs were rewarded for the number of tests given, while for subsequent years they received target payments if they screened at least a specified proportion of women aged 25-64 on their list. Since information on cytology screening is generated only in connection with payments to GPs we ensure longitudinal comparability by measuring the quality of screening by the FHSA's *z-score* (Armitage and Berry, 1994).[17]

To control for FHSAs characteristics that may affect the costs of administering a given number of primary care practitioners delivering care a given quality, we used the health of the

[16] In their analysis of hospital cost functions Scott and Parkin (1995) argued that because wages are set by national bargaining, it is reasonable to assume that labour input prices are the same across units and consequently, can be dropped from the estimation. However, in order to account for longitudinal variation in input prices we decided to keep labour input prices in the analysis.

[17] The primary care quality index is calculated as $z_{it} = (x_{it} - \bar{x}_t) / s_t$, where x_{it} represents the number of cervical cytology tests per eligible population or the proportion of GPs reaching the target of 90% screening for the eligible population in area *i* in year *t*, $\bar{x}_t$ is its mean value in year *t* and s_t is its standard deviation in year *t*.

population as measured by its standardised mortality rate and the population density per hectare.

4. Model specification and estimation

4.1 Specification of the cost function

We assume that the administrative cost function is multiplicatively separable between the effort and the other variables: $C_{it} = f_t(x_{it},x_i,q_{it},w_{it})e^{-ait}$. We deflate administrative cost by the input price index and express the dependent variable as the log of the real value of administrative costs. Some of the explanatory variables have zero values for some areas in some years (and all areas had a zero fundholding proportion before 1991/2). We therefore adopt the suggestion of Caves et al. (1980) and use the generalised translog multiproduct cost function, where the log metric is used for total costs and input prices, and the Box-Cox metric is adopted for the "outputs" (numbers of GPs, dentists etc) and other area characteristics. This functional form has been extensively used in the estimation of cost function in the health care sector.[18] The cost function is

$$\begin{aligned} \ln c_{it} = & \sum_j \varphi_j \left((x_{jit}^{\lambda} - 1)/\lambda\right) + \frac{1}{2}\sum_j \sum_k \varphi_{jk}\left((x_{jit}^{\lambda}-1)/\lambda\right)\left((x_{kit}^{\lambda}-1)/\lambda\right) \\ & + \omega\left((q_{it}^{\lambda}-1)/\lambda\right) + \sum_m \theta_m \left((y_{mit}^{\lambda}-1)/\lambda\right) + u_{it} \end{aligned} \qquad (23)$$

The x_{jit} are the numbers of GPs, practice nurses, ophthalmic medical practitioners, dentists and community pharmacies administered by the FHSA, q_{it} is the quality index, and y_{mit} are characteristics of the areas, other than their primary care practitioners administered by the FHSA. The term u_{it} reflects the effect of unobservables including managerial effort. The transformation parameter λ is to be estimated and nests the linear ($\lambda = 1$) and log-linear forms ($\lambda = 0$).

The cost elasticity with respect to the j-th output is

$$\eta_j = \frac{\partial \ln c}{\partial \ln x_j} = \left[\varphi_j + \sum_k \varphi_{jk}\left((x_j^{\lambda}-1)/\lambda\right)\right] x_j^{\lambda} \qquad (24)$$

We standardised the data by dividing the explanatory variables by their mean in 1994/95, so we can interpret the coefficients on the linear terms as cost elasticity evaluated at the 1994/5 mean values of the explanatory variables.

The degree of economies of scale (*SCE*) is the proportionate increase in total cost resulting from a proportionate increase in all the practitioners. With the generalised translog cost function SCE varies with scale and is measured as the inverse of the sum of the cost elasticities with respect to the practitioners (Caves et al., 1984)

$$SCE = 1/\sum_j h_j \qquad (25)$$

4.2 Estimation

We estimated the generalised translog cost function (23) on data from 1989-90 to 1994-95 using both fixed effect and random effect panel data procedures. Initial investigations indicated heteroskedasticity, with the variance of the errors greater for small FHSAs, perhaps because small FHSAs are more likely to have their administrative costs affected by fixed costs. For the fixed effect model we therefore apply the White-correction to the standard errors (Arellano, 1987).

The theoretical model in section 2 suggested that endogenous quality may produce bias in the estimated coefficients. It is also possible that the proportion of GP fundholders may not be exogenous (Baines and Whynes, 1996) since GPs could choose to become fundholders or not and their decisions may be related to characteristics of their practices and of the FHSA. We tested for simultaneity by re-estimating the fixed effect cost function using instrumental variables.[19] The Davidson and MacKinnon (1993) test did not reject the hypothesis that both quality and the proportion of fundholders are exogenously determined.[20]

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[18] See for example Fournier and Mitchell (1992), Dor and Farley (1996), and Wholey et al (1996).

[19] The instruments used in the IV estimation were the proportion of GP practising as solo practitioners, the proportion of GP aged 65 or older, the GP/population ratio, the ratio of practice nurses to GPs, and the squared values and the interaction between the last two instruments.

[20] The Davidson and MacKinnon (1993, pp. 236-242) exogeneity test yields the value of F(2, 419) = 1.79, which is well below the significance level (*p.* = 0.1678). The F-statistics of the identifying instruments in the auxiliary regressions showed that the instruments were highly significant, and the overidentifying (OID)

5. Results

Table 2 reports the estimates of the cost function (23) including the linear, quadratic and cross product terms.[21] The estimated economies of scale factor (SCE) is evaluated at the 1994/5 means of the explanatory variables and since the variables are standardised at their 1994/5 means the estimated linear terms on the primary care practitioners are the elasticities of administrative cost with respect to the numbers of GPs, dentists etc. The fixed effects model is reported in the first two columns and has positive and significant linear terms for general practitioners and practice nurses, the linear term for opticians is positive but not statistically significant and those for dentists and pharmacies are negative, though not significant. The last two columns in Table 2 present the estimates of the random effects model. We argued in section 2.3 that endogenous managerial effort implied that the random effects specification was likely to be misspecified. The Hausman (1978) test indicates that the assumption that area effects are not correlated with the other regressors cannot be rejected[22] and so the random effects model is appropriate.

The model of managerial effort in section 2.1 implies that effort will be correlated with the number of practitioners if the marginal cost of practitioners is reduced by managerial effort (C_{aq} <0) and if the manager cares about administrative costs ($b_1 > 0$). The assumed cost function is of the form $C=f(x,q)h(a)$ which implies $C_{aq} < 0$. Since b_1 reflects both managerial preferences and the incentive structure in primary care administration, the fact that the Hausman test indicates that area effects are not correlated with practitioners suggests that incentives to reduce primary care administration costs are negligible.

The random effects model yields economically more sensible results since all the linear cost terms on the primary care practitioners are positive. Further, the random effects model produces much modest prediction errors because, unlike the fixed effects model, it does not

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restrictions test (Godfrey and Hutton, 1994) suggested that the instruments were valid and the model was not misspecified ($c^2(5)$ = 9.612; $p.$ = 0.103).

[21] The value of l was chosen to maximise the log-likelihood of the regression and was determined using a grid search as suggested by Dor and Farley (1996). The search range was -2.0 and +2.0, with intervals of 0.01.

[22] The Hausman procedure tests the assumption that the disturbances do not contain individual invariant effects which are unobserved and correlated with the independent variables by comparing the coefficients provided by the fixed and by the random effects models. If the assumption is correct, the coefficients estimated by the two models are not systematically different and the random effects model is more efficient.

have to sacrifice a large number of degrees of freedom in estimating area effects. This is important when assessing economies of scale or scope.

Both models indicate that the number of general practitioners has the largest proportionate effect on costs. This is plausible since the remuneration system for GPs is much more complicated than for other practitioners. Density of population is significantly positively associated with administrative costs in the random effects model. Since the variable shows relatively little change over time it may be picking up area effects. One possibility is that more densely populated areas have greater turnover of patients on GP lists and so generate more administration. The regional dummies are also of the expected sign, indicating that Inner London areas have significantly higher administrative costs than more rural areas and also than other urban areas, probably because of differences in property rents.

5.1 Economies of scale

Both models suggest that that there are economies of scale exist in the administration of primary care. The fixed effects model estimates that the *SCE* is equal to 1.543 but this is not significantly different from unity. The random effects model estimate indicates a more modest *SCE*, 1.209 which is statistically different from unity because the random effects estimates are more precise. The random effects model suggests that there are economies of scale to be exploited at the mean 1994/5 size of FHSA.

Figure 1 illustrates the impact of scale on costs for non local variations in scale. It is derived by calculating the administrative cost of an FHSA from the fixed and random effects models when the primary care practitioner variables are increased or decreased proportionately from their mean 1994/5 values and the values of all other explanatory variables are held constant at their 1994/5 means. The curves plot the resulting total costs divided by the scale factor for the primary care practitioner variables and can be regarded as the multi-"output" analogue of single output average cost function.

The curve derived from the fixed effect model is “U” shape and indicates the presence of economies of scale for small and medium-sized FHSAs. Economies of scale are exhausted at a level 20% larger than the average FHSA

The average cost curve estimated by the random effects model is similar to the fixed effects model for scales of production near to the mean. Economies of scale are much less for small FHSAs. The random effects model suggests that there are economies of scale at all level of production.

The fact that both models suggest marked economies of scale for small FHSAs may have some implications for possible future developments in the administration of primary care in England. The NHS was reorganised around Primary Care Groups (PCGs) April 1999. PCGs consist of around 50 general practitioners with total lists of about 100,000 patients - they are about one fifth the size of Health Authorities, some of whose functions they have taken over. Our estimates suggest that there could be adverse consequences for administrative costs if PCGs take over all of the primary care administrative tasks previously carried out by FHSAs.

5.2 Economies of scope

There are economies of scope if the cost of administering a given set of primary care practitioners is less than sum of the costs of administering them separately (Baumol et al, 1982). One way to measure economies of scope is as the proportionate change in costs from partitioning the practitioner types into two groups (Fournier and Michell, 1992):

$$\frac{C(x^1,0,\cdot)+C(0,x^2,\cdot)-C(x^1,x^2,\cdot)}{C(x^1,x^2,\cdot)} \qquad (26)$$

where x^1, x^2 is a partition of the practitioner vector.

Table 3 reports estimated economies of scope for six possible partitions: each practitioner type separately administered from the rest and practice nurses and GPs administered separately from all other practitioners.[23] The cost changes are calculated at the 1994/5 means. Whilst some of the cost differences are large, only that for separate administration of practice nurses is significant.

[23] The economies of scope estimated by the fixed effects model are similar but not significant.

5.3 Fundholding and administration costs

The introduction of fundholding in April 1991 increased the tasks which FHSAs were expected to carry out. We included the proportion of fundholding practices to reflect this change in function. The regression indicates that fundholding had a significant positive effect on costs, though its magnitude is small. Table 4 presents the estimated administrative costs of the associated with fundholding both in absolute terms and as a proportion of total administrative costs. Fundholding accounts for 3.5-4.3% (as depending on whether the fixed and random effects estimates are used) of the expenditure in administration in the financial year 1994/95 which is between £7.7M - £11M.

5.4 Changes in administration cost over time

Administration cost changes over time for three reasons: changes in the cost drivers (outputs, quality and control variables); changes in the price of inputs; and shifts in the cost function across all FHSAs (reflected in the year dummies in Table 2). The first column in Table 5 shows the proportionate change in the cost each year. The second column is the change in costs which would have occurred due solely to the shift in the cost function with the drivers and input prices held constant. The third and fourth columns give the proportionate changes in costs which would be attributable solely to changes in the drivers and in the input prices respectively. It is apparent that the changes in the number of practitioners, quality levels etc have had relatively little effect on total cost over the period. The effect of input price inflation is greater but still minor compared with the shifts in the cost function.

The shift of the cost function over time could be the reflection of a number of factors:

(i) there may have been “negative technical progress”: the technology altered to make it more costly to administer primary care. This seems implausible.

(ii) Factor price changes may have not been fully allowed for in our deflation of administrative costs by input price indices. Our input price index is imperfect but it is difficult to believe that there were increases in the prices of inputs used in administering primary care which are capable of explaining the more than doubling of administrative costs over the period.

(iii) An increase in the administrative tasks performed by FHSAs. The fundholding variable is a direct measure of some of the new administrative tasks associated with the internal market and is included in the cost drivers. Since other additional administrative tasks were not associated with fundholding, the fundholding variable may be an inadequate proxy for all the increased tasks resulting from the internal market reforms of the early 1990ies.

Total administrative costs of FHSA were £215M in 1994/5 (current prices) and we estimate that cost increased between 1989/90 and 1994/5 by 123% as a result of shift in the cost function, rather than to changes in its arguments. If the year dummies are picking up the effect of the increase in administrative tasks, we have identified a further large cost of the 1990 reforms.

5.5 Relative efficiency

The estimated cost function can be used to derive an estimate of the difference in costs due to unobserved area effects, using the estimated fixed effects or, in the case of the random effects model, from the area residuals. We calculate the cost effect as the percentage difference between the cost of the area given its estimated fixed effect and the cost it would have with the area average fixed effect: $\exp\{F_i - \overline{F}\} - 1$ where F_i is the estimated area fixed effect and $\overline{F}$ is the mean fixed effect. Figure 2 presents a "league table" for the areas with above average fixed effects and plots the estimated area cost effects and their confidence intervals.

Such area effects have been interpreted as an indicator of efficiency (Schmidt and Sickles, 1984) but we argued in section 2.2 that necessary conditions for this interpretation are that the number of primary care practitioners and the quality of primary care are exogenous as far as managers are concerned and the effort of managers has negligible social cost. Even if these conditions are satisfied we showed in section 2.3 that the area effects would yield biased estimates of the differences in managerial effort.

The size of the confidence intervals also indicates that one should be extremely cautious in using these results to label areas as more or less efficient in terms of their administrative costs. Figure 2 shows that only a few of the "inefficient" or high cost FHSAs have a cost effect which is significantly above the mean. The analysis may however be useful as an initial filter to select areas for further investigation after allowing for differences in costs associated with routinely observable factors such as the number of practitioners.

6. Conclusion

A simple theoretical model of managerial effort to reduce administrative costs reinforces previous cautions about the interpretation of the results of studies of inefficiency in health care. Estimated differences in costs measure welfare differences across units only if relevant decision makers cannot control outputs or quality and if the unobserved effort costs have negligible social significance. Further, estimates of cost differences as area fixed effects or as residuals from random effects models are unlikely to be unbiased if managerial effort is endogenous. The lesson is that empirical investigation of cost functions needs to rest on careful specification of the decision generating those cost functions.

Our investigation of the costs of administering primary care in the NHS suggests:

- numbers of general practitioners had the greatest effect on administration costs;
- there were unexploited economies of scale in primary care administration;
- the introduction of fundholding had a significant but relatively small positively impact on costs;
- most of the doubling of costs over the period 1989/90 - 1994/5 is attributable to shifts in the cost function, most likely reflecting unmeasured increases in administrative tasks, including those following the changes to the GP contract in 1990;
- regression based comparison of administrative costs across FHSAs shows that only a small number can be said to be significantly more costly *ceteris paribus* than average. Policy to reduce administration costs may be best directed at improving the performance of all areas, perhaps by introduction of incentive schemes, rather than by concentrating attention on the few obviously high cost areas.

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Table 1 Description of the variables

Variable	Mean	Std. Dev.	Min	Max
Administrative costs in '000 £				
Financial year 1989/90	741.39	371.01	257.1	1916.83
Financial year 1990/91	1154.64	505.51	502.04	2618.17
Financial year 1991/92	1514.80	609.08	706.03	3181.71
Financial year 1992/93	1798.67	787.46	822.47	5287.41
Financial year 1993/94	2160.38	995.72	731.23	6533.2
Financial year 1994/95	2391.20	1168.82	902.35	7293.67
Descriptive statistics for the entire sample				
Administrative costs in '000 £	1626.85	968.56	257.1	7293
No. of General medical practitioners (GPs)	287.16	174.02	69	900
No. of Practice nurses	89.77	64.89	0	396
No. of Dentists having contract with the FHSA	172.87	109.20	38	540
No. of Ophthalmic opticians having contract with the FHSA	137.93	83.39	15	523
No. of Community pharmacies	108.22	62.51	28	305
% of Fundholders	11.06	11.30	0	58.04
Population density (population per hectares)	17.80	20.19	0.61	100.76
Quality of cervical cytology tests (*z-values*)	10.00	1.00	6.36	12.27
Standardised mortality rate (SMR)	102.10	10.44	76.7	136.5

Table 2 Parameter estimates of the cost function

	Fixed effects model		Random effects model	
Variable	Coefficients	Standard Error	Coefficients	Standard Error
General practitioners (x_1)	0.603**	0.286	0.650***	0.102
Practice nurses (x_2)	0.063*	0.033	0.066*	0.034
Dentists (x_3)	-0.035	0.165	0.009	0.069
Opticians (x_4)	0.045	0.048	0.084***	0.032
Pharmacies (x_5)	-0.027	0.346	0.019	0.082
% of Fundholders	0.036**	0.017	0.046***	0.016
Quality of cervical cytology test	0.188*	0.098	0.057	0.097
Population density	0.296	0.473	0.055***	0.019
SMR	0.043	0.065	0.061	0.073
$x_1 \times x_1$	1.364*	0.708	-0.033	0.340
$x_2 \times x_2$	0.083	0.054	0.065	0.066
$x_3 \times x_3$	0.972	0.629	-0.296	0.349
$x_4 \times x_4$	-0.143*	0.075	-0.312***	0.075
$x_5 \times x_5$	-0.326	0.639	-0.351	0.365
$x_1 \times x_2$	0.058	0.148	-0.052	0.124
$x_1 \times x_3$	-0.531	0.413	-0.008	0.284
$x_1 \times x_4$	0.028	0.161	-0.248*	0.139
$x_1 \times x_5$	-1.096	0.710	-0.096	0.289
$x_2 \times x_3$	-0.179*	0.095	-0.090	0.086
$x_2 \times x_4$	0.023	0.051	0.045	0.055
$x_2 \times x_5$	-0.044	0.089	-0.029	0.085
$x_3 \times x_4$	-0.316**	0.143	0.145	0.125
$x_3 \times x_5$	0.105	0.450	0.322	0.250
$x_4 \times x_5$	0.409**	0.178	0.259**	0.127
Outer London [a]	-	-	-0.106*	0.054
Metropolitan areas [a]	-	-	-0.172***	0.057
Shire counties [a]	-	-	-0.261***	0.071
1990/91	0.389***	0.018	0.388***	0.019
1991/92	0.554***	0.021	0.556***	0.022
1992/93	0.633***	0.024	0.632***	0.025
1993/94	0.731***	0.026	0.726***	0.025
1994/95	0.806***	0.027	0.797***	0.026
Intercept	7.026	0.238	7.156***	0.063
l	1.04		1.04	
Estimated SCE	1.543		1.209	
Hausman test [c^2 (29)]	6.26			
R^2	0.929		0.925	
RESET [F(3, 418)]	0.96		0.10	
F-test that all $u_i = 0$ [F(89, 421)]	4.80***		-	
Breush-Pagan test [c^2 (1)] [b]	-		96.31***	
Test that SCE =1 [F(1, 421)]	0.27		22.69***	

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

a: These variables are not included in the fixed effects model as they are time invariant.

b: The Breush and Pagan test that Var (u_i) = 0.

Table 3 Estimated economies of scope

Service Mix	Estimated economies	Probability level
General practitioners vs. Others	19.26%	p. > 0.6267
Practice nurses vs. Others	26.89%	p. > 0.0500
Dentists vs. Others	-1.88%	p. > 0.9535
Opticians vs. Others	-1.94%	p. > 0.8895
Pharmacies vs. Others	-6.75%	p. > 0.8286
General practitioners, Practice nurses vs. Others	21.70%	p. > 0.5549

Estimated using the random effects model

Table 4 Estimated administrative cost of fund-holder scheme

	Fixed effects model		Random effects model	
Financial year	Cost £ '000	% of total administrative cost	Cost £ '000	% of total administrative cost
1989/90	£0	0%	£0	0%
1990/91	£538	0.49%	£758	0.61%
1991/92	£1,436	0.98%	£2,034	1.22%
1992/93	£3,690	2.17%	£5,227	2.67%
1993/94	£5,943	2.95%	£8,427	3.59%
1994/95	£7,770	3.55%	£11,009	4.30%
Total	£19,378	2.11%	£27,454	2.60%

Table 5 Estimated changes in the cost function

Financial year	% change in cost	% change due to changes in		
		shift in the cost function [a]	cost driver [a]	input price
1989/90 - 1990/1	0.61	47.51	-0.36	9.70
1990/1 - 1991/2	0.33	18.01	2.22	10.24
1991/2 - 1992/3	0.17	8.20	2.19	6.21
1992/3 - 1993/4	0.20	10.25	2.15	6.15
1993/4 - 1994/5	0.09	7.78	0.91	0.39

a: Estimated using the random effects model

Figure 1 Estimated average cost curve

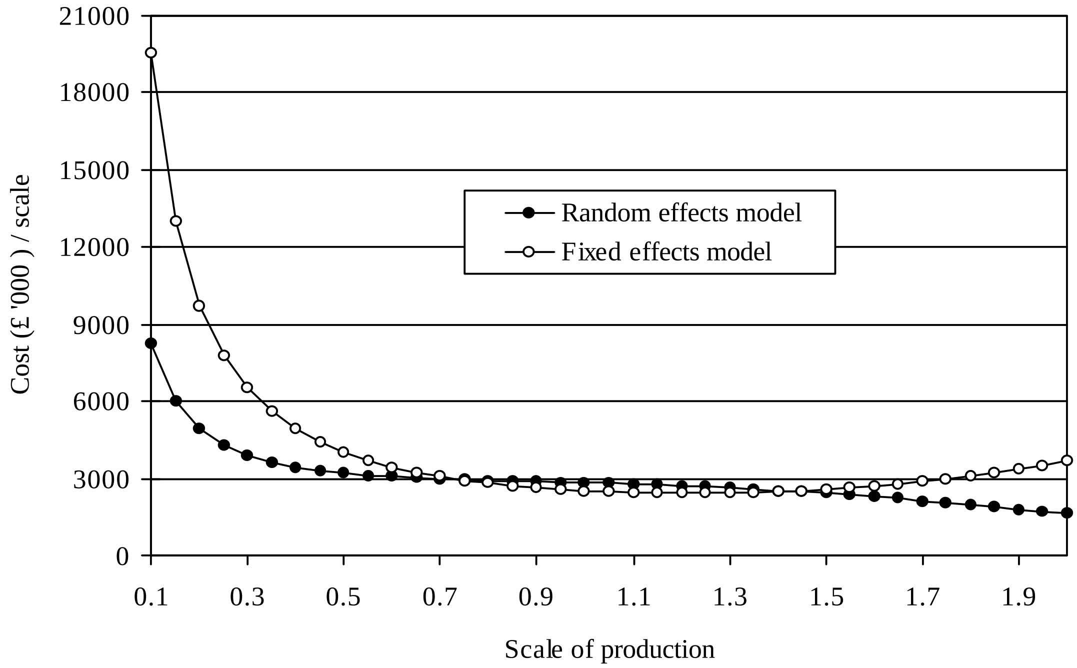

Figure 2 Estimated cost effects for higher cost FHSAs