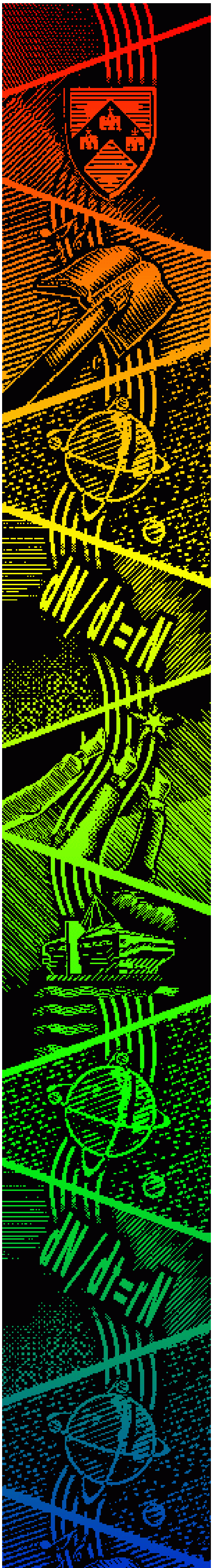
THE UNIVERSITY of York



Discussion Papers in Economics

No. 2006/05

Competition and Resource Effectiveness in Education

by

David Mayston

Department of Economics and Related Studies
University of York
Heslington
York, YO10 5DD

COMPETITION AND RESOURCE EFFECTIVENESS IN EDUCATION

by

DAVID MAYSTON

University of York

ABSTRACT

This paper examines the impact of competition in the markets for teachers and for housing on the long-standing issue of the influence of school resourcing on educational attainment. The existence of such competition is found to imply not only downward bias in many earlier empirical estimates of the role of resources in the educational production function, but also powerful general equilibrium effects, especially for the impact of *relative* levels of school resources upon the distribution of *relative* levels of educational attainment across individual schools, that highlight the importance of how resources are distributed across individual schools. The paper derives optimal resource allocation rules for distributing government educational budgets across individual schools and examines the properties of the associated funding formulae.

1 INTRODUCTION

Raising levels of educational attainment has been a central policy goal in the UK and elsewhere in recent years. Towards this end, substantial additional resources have been devoted to the education sector, particularly for primary and secondary education (HM Treasury, 2004). However, a long-standing issue in the academic literature (e.g. Coleman, 1966; Hanushek, 1986, 1997; Kreuger, 1999), with econometric and (micro- and macro-) economic policy implications, is whether or not such additional resources from increased levels of public expenditure do result in improved levels of educational attainment in schools. At the same time, increased competition between individual schools has been introduced through 'quasi-market' reforms in the education sector. As noted in Le Grand and Bartlett (1993), Bradley et al (2000), and Bradley and Taylor (2002), such a 'quasi-market' in education is characterised by schools possessing a high degree of independence in their decision-making and budgetary management, and competing for the available pupils in the presence of publicly available information on their educational performance in examinations on a common national curriculum. Such 'quasi-market' reforms, however, tend to reinforce the importance for each individual school of the existence of competition in two important actual markets, namely the labour market for teachers and the property market for local housing. In this paper we will examine the importance of competition in these two markets for the impact which additional resources for schools are likely to have upon levels of educational attainment.

2 THE EDUCATIONAL PRODUCTION FUNCTION

For the sake of concreteness, we will assume that in the country, or region, of interest (denoted by Ω), there exist $r > 1$ localities, with each locality $\ell \varepsilon \Omega$ containing an equal number n_1 of households, and a single school, namely school ℓ to whom all households in the locality are required to send their children of school age. Φ_ℓ will denote the set of households who decide to locate in locality ℓ. We will assume in this paper that all households contain the same number, n_2 , of children of school age, with $n \equiv n_1 n_2$ denoting the number of children in each school. The educational production function for school ℓ is assumed to be of the Cobb-Douglas form:

$$q_\ell = A_\ell Y_{o\ell}^{\beta_2} Q_\ell^{\beta_3} T_\ell^{\beta_4} K_\ell^{\beta_5} \quad \text{with } A_\ell = A\nu_{\ell 1} \tag{2.1}$$

where A is a constant, q_ℓ denotes school ℓ's level of educational achievement per pupil (as reflected in public examination results), T_ℓ its teacher-pupil ratio, K_ℓ its supporting capital facilities per pupil, Q_ℓ an index of its teacher quality, and $Y_{o\ell}$ the (geometric) mean level of household income in locality $\ell \varepsilon \Omega$. $\nu_{\ell 1}$ is assumed to be a lognormally distributed stochastic term (with a zero mean to $\ln\nu_{\ell 1}$) that reflects other less directly measurable factors, such as the school's 'ethos' (Rutter et al, 1979), that may contribute to its educational efficiency and effectiveness.

The positive role of teacher quality in influencing educational attainment has been stressed by Winkler (1975), Summers and Wolfe (1977) and Murdane (1996). The positive influence on educational attainment of parental income (and of variables, such as parental education, that tend to be positively correlated with parental income) is stressed by Haveman and Wolfe (1995), Ermisch and Francesconi (2001) and Lee and Barro (2001). We will also investigate the implications of the assumption that more resources, in the form of higher values of T_ℓ and K_ℓ, are productive in improving the school's level of education attainment, q_ℓ, with $\beta_k > 0$ for k = 2,...,5 in (2.1).

The log-linear regression equation corresponding to (2.1):

$$\ln q_\ell = \beta_o + \beta_2 \ln Y_{o\ell} + \beta_3 \ln Q_\ell + \beta_4 \ln T_\ell + \beta_5 \ln K_\ell - u_{\ell 1} \tag{2.2}$$

where $\beta_0 \equiv \ln A$ and $u_{\ell 1} \equiv -\ln \nu_{\ell 1}$, may be written in the form:

$$\sum_{k=1}^{5} y_{\ell k} b_{k1} = -b_{01} + u_{\ell 1} \text{ with } b_{11} = -1, b_{k1} > 0 \text{ for } k = 2,\ldots,5 \tag{2.3}$$

where $y_{\ell 1} \equiv \ln q_\ell$, $y_{\ell 2} \equiv \ln Y_{o\ell}$, $y_{\ell 3} \equiv \ln Q_\ell$, $y_{\ell 4} \equiv \ln T_\ell$, $y_{\ell 5} \equiv \ln K_\ell$, , $E(u_{\ell 1}) = 0$, $b_{k1} \equiv \beta_k$ for k = 0, 2,...,5. For each k, the mean value of $y_{\ell k}$ for $\ell \varepsilon \Omega$ will be denoted by $\bar{y}_k$.

3 COMPETITION FOR SCHOOL PLACES

While selection by academic ability has not been a predominant feature of publicly-funded schools in the UK and elsewhere for several decades, an important *proxy market* in which parents can compete for the right to send their children to a particular school is that of the housing market. Residence in a location within what is effectively the catchment area of the school will typically convey a form of property right of access to the given school, in contrast to location elsewhere. In the decision by parents of whether or not to locate in the catchment area of school ℓ, an important consideration on the demand side of the housing market will be the preferences of each household i with respect to examination results, school resources and teacher quality. Their preferences will also be dependent on the level of the local housing services, H_ℓ, and of other local amenities $N_{\ell g}$ for all g = 1,...,χ that residence in locality ℓ confers, as well as on the level of their private consumption, C_i, of non-housing services that their income, Y_i, and local house prices permit. The utility level of household i if it does locate in locality ℓ is assumed to be given by:

$$U_{i\ell} = U(C_i, L_\ell, H_\ell, N_\ell, \psi_\ell) = C_i^{\gamma_0} L_\ell^{\gamma_1} H_\ell^{\gamma_2} N_\ell^{\gamma_3} \psi_\ell \text{ with } N_\ell = \prod_{g=1}^{\chi} N_{\ell g}^{t_g} \qquad (3.1)$$

where H_ℓ is the level of local housing services in locality ℓ and N_ℓ an index of local amenities, in which the t_g are positive constants, with $\gamma_k > 0$ for k = 0,...,3. The index, L_ℓ , of local school quality is assumed to be of the form:

$$L_\ell = q_\ell^{\rho_1} Q_\ell^{\rho_3} T_\ell^{\rho_4} K_\ell^{\rho_5} \text{ where } \rho_k > 0 \text{ for } k = 1,3,4,5 \qquad (3.2)$$

so that parents may value not only the current level of examination success, q_ℓ , of the school, but also the quality of its teachers and its resourcing levels, T_ℓ and K_ℓ , per pupil. The quality of local schooling that L_ℓ reflects will provide a *local public good* for households $i \varepsilon \Phi_\ell$. Any other residual attractions of living in locality ℓ that are not captured by the other measurable characteristics in (3.1) are assumed to be incorporated in the stochastic variable $\psi_\ell > 0$ that is assumed to be independently lognormally distributed, with a mean to $\ln \psi_\ell$ of zero.

Families are assumed to face a budget constraint of the form:

$$C_i + p(L_\ell, N_\ell, \psi_\ell)H_\ell = Y_i \qquad \text{for } i \varepsilon \Phi_\ell \tag{3.3}$$

where p is the *hedonic price function* (see Rosen, 1974; Freeman, 1979; Sheppard, 1999) which households face in the housing market per unit of annual housing services for living in locality ℓ, and thereby being able to enjoy a school of quality L_ℓ, with local amenities of quality N_ℓ, and other attractions reflected in ψ_ℓ. The endowment of housing stock in locality ℓ is assumed to be fixed, with an equal number, n_1, of residences and households in each locality, and a total number, $r\ n_1$, of available residences across all localities that equals the total number of households, n_o, in the population at large. Competition in the housing market is assumed to bid up the price, p, per unit of housing to achieve equality with the local willingness to pay, P, for additional units of housing service per annum, as reflected in the marginal rate of substitution between housing services and private consumption, C_i, of non-housing services given by the utility function in eqn (3.1), i.e.

$$p = P = \gamma_2 C_i / (\gamma_o H_\ell) \text{ for } i \in \Phi_\ell \quad (3.4)$$

Substitution of (3.4) into (3.3) also implies that:

$$C_i = \gamma_o Y_i / (\gamma_o + \gamma_2) \quad (3.5)$$

Eqns (3.1) - (3.5) generate the *household bid function* (Yinger, 1982), of household i's maximum willingness to pay, to locate in locality ℓ:

$$P(S_\ell, Y_i) = S_\ell^{1/\gamma_2} Y_i^{\gamma_5} \text{ where } S_\ell \equiv \gamma_4 L_\ell^{\gamma_1} N_\ell^{\gamma_3} \psi_\ell \quad (3.6)$$

where γ_4 is a positive constant, $\gamma_5 \equiv (\gamma_o + \gamma_2)/\gamma_2 > 0$, for a given maximum utility level obtainable elsewhere. We will assume that the total number of localities, r, is arbitrarily large and that the variables which define S_ℓ in (3.6) are distributed according to a multivariate lognormal distribution across localities $\ell \in \Omega$, implying from Aitchison and Brown (1963, p. 12) that S_ℓ is also lognormally distributed across localities $\ell \in \Omega$.

Under competition in the housing market, house prices per unit of housing stock are an increasing function in (3.6) of the quality of local schooling, as reflected in the index L_ℓ, as well as of the local amenities, N_ℓ, and other residual attractions, ψ_ℓ. As in (3.2), the quality of local schooling may be judged not only by the examination results achieved by the local school but also by the quality of its teachers and the level of its resources per pupil. A significant positive impact of local school variables on local house prices, alongside local amenity characteristics and housing attributes, has been reported by several empirical studies.

Oates (1969) reported a significant positive association of local house prices with school expenditure per pupil, whilst Haurin and Brasington (1996) concluded that school examination success, as measured by ninth grade test score results, “is the most important cause of the variation in constant-quality house prices”. In assessing the impact of a broad range of school variables, Brasington (1999) reports proficiency test scores, expenditure per pupil and the pupil-teacher ratio, as well as average teacher salary, to be consistently positively related to house prices, with teacher experience and education levels and pupil value added measures less significant. In studies of UK local housing markets, Cheshire and Sheppard (1998), and Leech and Campos (2001), report strongly significant impacts on house prices of dummy variables for being in the catchment areas of particular popular local secondary schools. A similar significant positive relationship between house prices in suburbs of Boston, Massachusetts and elementary school test scores for similar houses along the boundaries of school catchment areas is interpreted by Black (1999) as revealing the magnitude of parental willingness to pay for increased educational achievement.

Parental willingness to pay in (3.6) is also an increasing function of household income, Y_i, which we assume to be lognormally distributed across households in the population at large. Competition between families in the housing market for location in area ℓ will then result in a *sorting* of families into localities according to income. From (3.6), we have for all S_ℓ , $Y_i > 0$:

$$\partial P / \partial S_\ell > 0, \;\; \partial^2 P / \partial S_\ell \partial Y_i > 0 \;\; for \; i \varepsilon \, \Phi_\ell \qquad (3.7)$$

The slope of the household bid function with respect to S_ℓ here increases monotonically with household income Y_i. This implies that the indirect indifference curves that are mapped out by (3.6) exhibit the "single-crossing" property (see Ross and Yinger, 1999) with respect to Y_i, that in turn yields an ordering of household types along the S_ℓ axis, in which those households with the highest Y_i values have the highest willingness to pay for high local community benefits S_ℓ. Under competition in the housing market, those with the highest willingness to pay succeed in securing the highest community benefits S_ℓ, and those households further down the distribution of income receive correspondingly lower levels of community benefits S_ℓ from within the available distribution of S_ℓ across localities $\ell \varepsilon \Omega$. When demand is equated to supply in the housing market for residence in each of these different localities under the above assumptions, those households in the highest x per cent of the income distribution across the population at large will receive community benefits S_ℓ at a level which falls in the highest x per cent of the distribution of S_ℓ across localities $\ell \varepsilon \Omega$, for all $100 \geq x > 0$. When we denote by F the cumulative lognormal distribution function for household income Y_i across households and by G the cumulative lognormal distribution function for S_ℓ across localities, this implies:

$$F(Y_i) = G(S_\ell) \qquad \text{for all } i \; \varepsilon \; \Phi_\ell \text{ for all } \ell \; \varepsilon \; \Omega \tag{3.8}$$

From (3.8) we have:

$$(\ln Y_i - \mu_Y)/\sigma_Y = (\ln S_\ell - m_S)/\sigma_S \quad \text{for all } i \; \varepsilon \; \Phi_\ell \text{ for all } \ell \; \varepsilon \; \Omega \tag{3.9}$$

where μ_Y is the mean value of $\ln Y_i$ across all households and σ_Y is its standard deviation, with m_S the mean value of $\ln S_\ell$ across all localities and σ_S its standard deviation. Under our assumption that the number of localities, r, is arbitrarily large, the above sorting process according to household income will result in homogeneous communities in which all households in the same locality have the same income level, and hence in which:

$$Y_{o\ell} = Y_i \text{ for all } i \;\varepsilon\; \Phi_\ell \text{ for all } \ell \;\varepsilon\; \Omega \tag{3.10}$$

(3.2), (3.6), (3.9) and (3.10) imply:

$$\sum_{k=1}^{5} y_{\ell k} b_{k2} = \sum_{k=1}^{5} \bar{y}_k b_{k2} - \sum_{g=1}^{\chi} (\ln N_{\ell g} - \eta_g) c_{g2} + u_{\ell 2} \tag{3.11}$$

where $b_{k2} = (\gamma_1 \rho_k \sigma_Y / \sigma_S) > 0$ for k = 1, 3, 4, 5, $b_{22} = -1$, $c_{g2} = (\gamma_3 t_g \sigma_Y / \sigma_S) > 0$, $u_{\ell 2} = -(\sigma_Y/\sigma_S) \ln \psi_\ell$, and where η_g is the mean level of the local amenity variable $N_{\ell g}$ across all localities $\ell \;\varepsilon\; \Omega$.

4 COMPETITION FOR TEACHERS

Adequate modelling of the role of teacher quality in influencing educational attainment needs to be accompanied by recognition of the factors which in turn may impact upon each school's teacher quality through competition in the labour market for teachers. Dolton's (1990) econometric finding of the importance of non-pecuniary factors in teacher supply decisions has been reinforced by survey evidence (Reid and Caudwell, 1997; Menter *et al*, 2002) of the importance of such factors for those considering entering or staying in teaching. Relevant non-pecuniary factors may include workload, pupil behaviour, administrative burdens, and the availability of supporting facilities for teaching (Coulthard and Kyriacou, 2002; Smithers and Robinson, 2003). School examination success may also impact upon the attractions of teaching in any given school, with Cuckle and Broadhead (1999, p. 184) finding a positive link between how favourable the school inspection report was and the impact on teacher morale and stress reduction. Law and Glover (1999), and Ladd and Walsh (2002), argue that school inspection and accountability systems tend to make insufficient allowance for disadvantaged pupil intakes and resource levels. As a result, “schools serving higher performing students are more likely to be deemed effective than schools serving low-performing students”, creating “incentives for these teachers to shun such schools in favor of other schools where they had a greater chance of being rewarded and a smaller chance of being sanctioned” (Ladd and Walsh, 2002, p. 5). In investigations into the determinants of teacher turnover, Smithers and Robinson (2004, 2005) similarly report teacher resignations from individual secondary schools to take up teaching posts elsewhere to be negatively related to the school’s examination performance, as well as positively related to eligibility for Free School Meal status, which in turn is negatively related to parental income.

Schools with more favourable teacher-pupil ratios, higher levels of supporting facilities per pupil, greater examination success and more advantaged family backgrounds may indeed find themselves with more well-qualified applicants for their available teaching posts, from whom they can select a higher quality of teacher. Schools with less favourable levels of these variables are likely instead to face staffing shortages, high teacher turnover and greater reliance upon temporary supply teachers, that reduce the effective quality of their teaching staff. Specifically, the quality, Q_ℓ, of teacher staff that school ℓ is able to attract will be assumed to be an increasing function of q_ℓ, T_ℓ , K_ℓ and $Y_{o\ell}$, of the form:

$$\ln Q_\ell = a_0 + b_{13} \ln q_\ell + b_{23} \ln Y_{o\ell} + b_{43} \ln T_\ell + b_{53} \ln K_\ell - a_6 / w_\ell - u_{\ell 3} \tag{4.1}$$

where $u_{\ell 3}$ is a stochastic disturbance term with zero mean, and $b_{k3} > 0$ for k = 1, 2, 4, 5.

Dalton (1990), and Dalton and van der Klaauw (1995), emphasise the importance also of relative earnings in teaching both for the initial decision to enter teaching and for teacher retention. Eqn (4.1) therefore includes the variable w_ℓ, to represent the wage which school ℓ pays to its teachers, with the quality, Q_ℓ , of teachers which school ℓ attracts an increasing function of w_ℓ , and diminishing towards zero as w_ℓ declines toward zero. From eqns (2.3), (3.11) and (4.1), we have:

$$\ln q_\ell = \alpha_{0\ell} + \alpha_4 \ln T_\ell + \alpha_5 \ln K_\ell - \alpha_6 / w_\ell + \nu_{\ell 3} \tag{4.2}$$

where $\alpha_k = -\sum_{j=1}^{3} b_{kj} a_{j1}$ for k = 4, 5, $\alpha_6 = -a_6 a_{31}$, $[a_{kj}] \equiv B_{11}^{-1}, B_{11} \equiv [b_{kj}]$ *for* $k, j = 1, 2, 3$, $\nu_{\ell 3}$ is a linear function of $u_{\ell 1}$, $u_{\ell 2}$ and $u_{\ell 3}$, and $\alpha_{o\ell}$ involves terms outside the control of school ℓ.

Each school ℓ is assumed to chooses its w_ℓ and T_ℓ to maximise q_ℓ in (4.2) subject to a budget constraint of the form:

$$w_\ell T_\ell \leq \nu_{\ell 4} \omega_{1T} R_\ell \tag{4.3}$$

where R_ℓ is the overall level of governmental funding per pupil to school ℓ, ω_{1T} ($1 > \omega_{1T} > 0$) is the proportion of government funding which the government allocates to schools for expenditure on teaching, and $\nu_{\ell 4}$ is a log-normally distributed stochastic disturbance term reflecting other, randomly available, sources of finance for teaching. Maximising (4.2) subject to (4.3) yields the following implication of the associated first order conditions:

$$w_\ell = \alpha_6 / \alpha_4 \text{ for all } \ell \; \varepsilon \; \Omega \tag{4.4}$$

(4.4) implies here that the same wage rate is paid to teachers by all schools in the competitive labour market for teachers. However, the quality of teachers that any individual school ℓ attracts depends upon the additional factors in (4.1) that influence the non-pecuniary attractions of the school to its potential teachers.

Each school is also assumed to face a budget constraint for its expenditure on supporting capital resources of the form:

$$\pi K_\ell \leq \nu_{\ell 5} \omega_{1K} R_\ell \tag{4.5}$$

where π is the unit price of capital facilities, $\omega_{1K} = 1 - \omega_{1T} > 0$ is the proportion of the government's overall funding per pupils for schools which it allocates to support each school's capital facilities, and $\nu_{\ell 5}$ is a log-normally distributed stochastic disturbance term reflecting other, randomly available, sources of finance for the school's capital facilities. From eqns (4.1) and (4.4), and with the $y_{\ell k}$ defined as in equation (2.3), we have:

$$\sum_{k=1}^{5} y_{\ell k} b_{k3} = -b_{03} + u_{\ell 3} \text{ where } b_{33} = -1,\ b_{k3} > 0 \text{ for } k = 1, 2, 4, 5 \qquad (4.6)$$

where $b_{03} = a_o - (\alpha_4 a_6/\alpha_6)$. Similarly with (4.3) and (4.5) holding with equality, we have:

$$\sum_{k=1}^{5} y_{\ell k} b_{kj} = -b_{0j} - \ln R_\ell + u_{\ell j} \text{ with } b_{jj} = -1,\ b_{kj} = 0 \text{ for } k(\neq j) = 1,..,5, \text{ for } j = 4, 5 \qquad (4.7)$$

where $b_{o4} = \ln\omega_{1T} - \ln(\alpha_6/\alpha_4)$, $b_{o5} = \ln \omega_{1K} - \ln \pi$, $u_{\ell j} = -\ln\nu_{\ell j}$ for j = 4, 5.

5 COMPETITION AND RESOURCE EFFECTIVENESS

When we define $y'_{\ell k}$ as the deviation of $y_{\ell k}$ from its mean value $\bar{y}_k$ across all localities, for each k =1,..., 5, eqns (2.3), (3.11), (4.6), and (4.7) require that the associated equilibrium values of each $y'_{\ell k}$ satisfy:

$$\sum_{k=1}^{5} y'_{\ell k} b_{kj} + \sum_{g=0}^{\chi} z_{\ell g} c_{gj} = u_{\ell j} \text{ for } \ell = 1,...,r \text{ and } j = 1,...,5 \qquad (5.1)$$

with $z_{\ell g} \equiv \ln N_{\ell g} - \eta_g$ for $g = 1,...,\chi$, $z_{\ell o} \equiv R'_\ell \equiv \ln R_\ell - R''$ where R'' is the mean value of $\ln R_\ell$ across all localities ℓ =1,…, r, $c_{04} = c_{05} = 1$, $c_{g2} > 0$ for g = 1,…, χ and $c_{gj} = 0$ otherwise. We may define $\varepsilon''_\ell \equiv (\delta y'_{\ell 1} / \delta R'_\ell)$ as the elasticity of the *relative level* of the educational performance, q_ℓ^o, of school ℓ with respect to increases in its *relative level* R_ℓ^o of government expenditure per pupil, where these relative levels are those relative to their respective geometric means, q^m and R^m, of educational performance and government expenditure per pupil, across all schools, as in (A13). We may also define $\varepsilon_\ell \equiv (\delta y_{\ell 1} / \delta \ln R_\ell)$ for k = 1 in (A10) as the elasticity of the *absolute level* of the educational performance, q_ℓ, of school ℓ with respect to increases in its *absolute level* of government expenditure per pupil R_ℓ. From (A11) and (A12), we then have:

$$\varepsilon_\ell'' > \varepsilon_\ell \tag{5.2}$$

i.e. each school's *relative* level of government expenditure per pupil exerts a more powerful influence upon its *relative* educational performance than the school's *absolute* level of government expenditure per pupil does on its *absolute* level of educational performance. Similar remarks apply to impact of absolute and relative levels of government expenditure per pupil on the other key variables $Y_{o\ell}, Q_\ell, T_\ell$ and K_ℓ for school ℓ.

We can also show from (A6) and (A10) – (A11) that:

$$\varepsilon_\ell' \equiv (\delta y_{\ell 1} / \delta R_\ell') > (\delta y_{\ell 1}' / \delta R_\ell') > (\delta y_{\ell 1} / \delta \ln R_\ell) \tag{5.3}$$

i.e. the proportionate impact, ε_ℓ', of an increase in the school's *relative level* of government expenditure per pupil on the *absolute level* of the school performance q_ℓ exceeds the corresponding proportionate impact of an increase in the school's relative level of government expenditure per pupil on the *relative level* of its educational performance. This in turn falls short of the impact on the corresponding *absolute level* of its educational performance of an increase in the school's *absolute level* of government expenditure per pupil.

From (A5), (A6), (A8) and (A9), we have for k = 1,...,5:

$$(d\overline{y}_k / dR'') = \gamma_k + \varphi_k \text{ where } \varphi_k \equiv \sum_{h=1,3}^{5} (d\overline{y}_h / dR'') b_{h2} D_{2k} < 0 \quad (5.4)$$

with $(d\overline{y}_k / dR'') > 0$ *for* $k = 1,3,4,5$ from (A6) and $(d\overline{y}_2 / dR'') = 0$. Hence from (A10):

$$(\delta y_{\ell k} / \delta \ln R_\ell) = \gamma_k + (\varphi_k / r) > 0 \text{ for } k = 1,...,5 \quad (5.5)$$

From (2.2), (2.3) and (5.5):

$$\varepsilon_\ell \equiv (\delta q_\ell / q_\ell)/(\delta R_\ell / R_\ell) = (\delta y_{\ell 1} / \delta \ln R_\ell) = \gamma_1 + (\varphi_1 / r) \quad (5.6)$$

$$= \beta_2(\delta \ddot{Y}_{o\ell} / \delta \ddot{R}_\ell) + \beta_3(\delta \ddot{Q}_\ell / \delta \ddot{R}_\ell) + \varepsilon_{\ell 0} > \varepsilon_{\ell 0} \equiv \beta_4(\delta \ddot{T}_\ell / \delta \ddot{R}_\ell) + \beta_5(\delta \ddot{K}_\ell / \delta \ddot{R}_\ell) > 0 \quad (5.7)$$

where $\delta \ddot{Q}_\ell$ denotes the proportionate change $\delta Q_\ell / Q_\ell$ etc and (2.3) and (5.5) imply that all the β's and all the terms in brackets in (5.6) and (5.7) are positive.

In the presence of the above competitive markets for teachers and for housing, the overall proportional impact, ε_ℓ, of additional resources per pupil for school ℓ upon the educational performance of pupils in school ℓ therefore exceeds the proportional increase, $\varepsilon_{\ell o}$, in (5.7) of the educational performance of school ℓ that is due to changes in the school's resource inputs per pupil, T_ℓ and K_ℓ. The impact of the changes in these resource variables via the resource coefficients β_4 and β_5 in the educational production function will here *understate the overall impact* of additional resources for school ℓ upon the educational performance of school ℓ.

6 RESOURCE EFFECTIVENESS AND ENDOGENEITY BIAS

(5.1) defines a set of 5 simultaneous linear equations in 5 endogenous variables and $\chi + 1$ predetermined variables. These are related through (2.3) to the underlying school variables of the teacher-pupil ratio, T, the supporting capital facilities per pupil, K, the mean level of local household income, Y, and an index of teacher quality, Q, (that may itself be derived from teacher qualifications and a measure of teacher turnover). In addition, they include the level of government funding per pupil, R, and the χ amenity variables that make up the local amenity index, N, in (3.1). The disturbance terms $u_{\ell j}$ in (5.1) are assumed to be independently normally distributed with zero means and variances of σ_j^2, and to be contemporaneously uncorrelated with each other.

We can now investigate the implications of applying OLS estimation to the first of these equations, namely the educational production function associated with (2.1)-(2.3), using the variables T, K, Y, Q, and R as regressors for the dependent variable of school examination performance, q. Given the set of simultaneous equations (5.1), the degree of asymptotic bias in the estimate of each regressor's coefficient β_k of the endogenous variables k = 2,...,5 associated with (5.1) may be shown, using Mayston (2005), to equal:

$$\theta_k^1 = -\frac{\sigma_1^2}{\xi_1}\sum_{j=2}^{5} b_{1j}(\beta_k b_{1j} + b_{kj}) / v_j^o \ \ where\ \xi_1 \equiv (1+\sigma_1^2 \sum_{j=2}^{5}(b_{1j}^2 / v_j^o)) > 0 \tag{6.1}$$

$$v_j^o \equiv \sigma_j^2 > 0\ for\ \ j = 3,4,5,\ \ v_2^o \equiv \sigma_2^2 + \kappa_{22}'' > 0,\ \kappa_{22}'' \equiv \mathrm{var}(\ln N)(1-\zeta_{RN}^2) \geq 0 \tag{6.2}$$

with the asymptotic bias in the OLS estimate of the regression coefficient of the predetermined variable ln R given by:

$$\theta_0^1 = -(\mathrm{cov}(\ln R, \ln N) / \mathrm{var}(\ln R))(\sigma_1^2 b_{12} / v_2^o \xi_1) - \sum_{j=2}^{5}(c_{0j}\sigma_1^2 b_{1j} /(v_j^o \xi_1)) \tag{6.3}$$

where ζ_{RN} in (6.2) is the correlation coefficient between $\ln R_\ell$ and $\ln N_\ell$ across schools $\ell\ \varepsilon\ \Omega$.

We can now determine the implications of our above analysis of competitive markets for teachers and for housing for the degree of asymptotic bias in the estimated coefficients of the resource variables in the educational production function under OLS. From (2.3), (3.11), (4.6), and (4.7), we have:

$b_{1j} > 0$ for j = 2,3, $b_{1j} = 0$ for j = 4,5; $b_{kj} > 0$ & $\beta_k > 0$ for k = 4,5 & j = 2,3;$b_{44} = b_{55} = -1$ (6.4)

implying from (6.1) and (6.2) that:

$$\theta_k^1 \equiv plim\ \hat{\beta}_k - \beta_k < 0 \text{ and hence } \beta_k^o \equiv plim\ \hat{\beta}_k < \beta_k \text{ for } k = 4,5 \qquad (6.5)$$

The OLS asymptotic estimates of the proportionate impact of a school's resource variables T_ℓ and K_ℓ on its educational performance will therefore *understate* the true coefficients of these resource variables in the educational production function. (6.3), (6.4) and (5.1) also imply downward asymptotic bias in the estimated coefficient on government funding per pupil, R_ℓ , whenever there is a positive correlation between government expenditure per pupil on a school and the level of local amenities. Such a positive correlation may indeed prevail if there is a high level of reliance of government funding for each school upon local taxation. From (5.7) and (6.5), we have:

$$\varepsilon_{\ell 0} \equiv \beta_4(\delta\ddot{T}_\ell / \delta\ddot{R}_\ell) + \beta_5(\delta\ddot{K}_\ell / \delta\ddot{R}_\ell) > \beta_4^o(\delta\ddot{T}_\ell / \delta\ddot{R}_\ell) + \beta_5^o(\delta\ddot{K}_\ell / \delta\ddot{R}_\ell) \equiv \varepsilon_{\ell 0}^o \qquad (6.6)$$

(A11), (5.3), (5.4) and (6.6) imply:

$$\varepsilon_\ell' > \varepsilon_\ell'' > \varepsilon_\ell > \varepsilon_{\ell o} > \varepsilon_{\ell o}^o \qquad (6.7)$$

From (A9)-(A12), (5.3), (5.5)-(5.7) and (6.6), each respective proportional impact $\varepsilon_\ell', \varepsilon_\ell'', \varepsilon_\ell, \varepsilon_{\ell o}$ and $\varepsilon_{\ell o}^o$ has the same value for all schools $\ell \in \Omega$. The regression-based estimate $\varepsilon_{\ell o}^o$ in (6.6) is the proportional impact on the absolute level of each school ℓ's educational achievements of a proportional increase in the absolute level of government funding per pupil for the school operating calculated using the asymptotic OLS estimates β_4^o and β_5^o of the resource coefficients of the educational production function. It falls short in (6.6) and (6.7) of the value of its impact, $\varepsilon_{\ell o}$, based upon the true coefficients β_4 and β_5 of the educational production function. This in turn is smaller than the overall proportional impact, ε_ℓ, of a proportional increase in the absolute level of government expenditure per pupil for the school on the school's absolute level of educational achievements in (5.6) and (5.7), when due account is taken of the impact of additional funding upon the attractiveness of the school in the competitive markets for teachers and local housing. ε_ℓ itself falls short of the proportionate impact, ε''_ℓ, on the school's *relative* educational achievements of a proportional increase in the school's *relative* level of government expenditure per pupil. The impact, ε'_ℓ, of a proportional increase in the school's relative level of government expenditure per pupil upon the school's *absolute* level of educational attainment is even greater than ε''_ℓ in (6.7). Small, and even negative, values to β_4^o and β_5^o in OLS regression studies, as in many of the empirical studies reviewed by Hanushek (1986, 1997), are then consistent with potentially large positive values to ε_ℓ, ε''_ℓ and ε'_ℓ in (6.7).

(5.5) also implies that for all $\mathrm{d}\ln R_\ell$:

$$\sum_{\ell=1}^{r}(\delta y_{\ell 1}/\delta \ln R_\ell)(d\ln R_\ell/dR'') = (\gamma_1 + (\varphi_1/r))r \tag{6.8}$$

Hence from (A9), (A13), (A4) and (A6) for all r >1:

$$0 < \varepsilon \equiv (d\ddot{q}^m/d\ddot{R}^m) = (d\overline{y}_1/dR'') = \gamma_1 + \varphi_1 < r\gamma_1 + \varphi_1 \tag{6.9}$$

$$= \sum_{\ell=1}^{r}(\delta y_{\ell 1}/\delta \ln R_\ell)(d\ln R_\ell/dR'') = \sum_{\ell=1}^{r}\varepsilon_\ell(d\ddot{R}_\ell/d\ddot{R}^m) \tag{6.10}$$

for all $(d\ddot{R}_\ell / d\ddot{R}^m)$. ε in (6.9) indicates the overall proportional impact on the (geometric) *mean level of educational achievement across all localities* in the given country or region Ω, of a proportional increase in the (geometric) mean level of government funding per pupil. The RHS of (6.10) is the sum of the proportional impacts on each individual school ℓ's absolute level of educational achievements in (6.10) of the proportional increases in each school ℓ's absolute level of level of government funding per pupil that are associated with a proportional increase in the mean level R^m of government funding per pupil. While it remains positive, the overall impact, ε, in (6.9) across the given country or region Ω as a whole will be *less than the sum* of the individual impacts on each school ℓ's educational achievements of additional government funding in (6.10) for school ℓ. In contrast to the analysis of Hanushek, Rivkin and Taylor (1996) of the effect of aggregation on omitted variables bias, a higher level of aggregation of examination performance above school level, such as at US State- or English LEA-level, will here tend to *understate* the influence of additional resources for an individual school upon the educational performance of the individual school.

In the presence of competitive markets for teachers and housing, additional government funding per pupil for any given individual school ℓ exerts a form of *negative externality* on the relative competitive position of all other schools t ≠ℓ, in the labour market for attracting higher quality teachers, and in the housing market for attracting more well-endowed parents. From (A5), (A6), (A8) and (5.4), we have for all τ ≠ℓ (τ εΩ), and for each k = 1,..,5:

$$(\delta y_{\tau k} / \delta \ln R_\ell) = \sum_{h=1,3}^{5} (\delta y_{\tau k} / \delta \overline{y}_h)(d\overline{y}_h / dR'')(dR'' / d \ln R_\ell) = \varphi_k / r < 0 \qquad (6.11)$$

so that additional government funding per pupil for school ℓ, holding constant that of other schools, will in equilibrium *reduce the absolute level* of each other school τ 's educational performance, as well as reducing the quality of teachers that other schools attract and the average income level of those parents who decide to locate in these other localities.

7 POLICY OPTIMISATION

There are a number of policy implications of the above analysis of the impact of competition:

a. additional resources will have a positive effect in raising educational attainment, and an effect that is greater than the estimates produced by earlier empirical studies that have relied on OLS estimation of the educational production function;

b. the impact of additional resources on the overall level of educational attainment of the country or region will, however, be less than that associated with the direct effect of additional resources on each individual school's level of educational attainment;

c. changes in the relative levels of government expenditure for individual schools exert an even more powerful influence on the school's educational attainment than do changes in their absolute levels, so that how resources are allocated across individual schools is of particular policy significance.

It is therefore of interest to examine optimal second-best policies for allocating resources to individual schools in the presence of the above competitive market constraints. One formulation of the objective function for such a policy is that of maximisation of a welfare function, W, that incorporates a constant coefficient, $\varsigma \geq 0$, of *relative aversion to inequality* (Atkinson, 1970) in the distribution of educational performance. In addition, we will assume that there is imposed an overall budget constraint that total government expenditure across all schools does not exceed the available total schools budget of R_T. We will specifically assume that the educational resource allocation policy seeks to maximise:

$$W \equiv \sum_{\tau=1}^{r} q_\tau^{1-\varsigma} / (1-\varsigma) \text{ subject to } \sum_{\tau=1}^{r} nR_\tau \leq R_T \quad (7.1)$$

for $\varsigma \neq 1$, with $W \equiv \sum_{\tau} \ln q_\tau$ *for* $\varsigma = 1$, and subject to the market-related constraints given by (2.3), (3.11), (4.6) and (4.7). Rather than express the second-best policy optimisation (7.1) subject to these constraints in the Lipsey-Lancaster (1956) form of involving numerous additional Lagrangean multipliers, we may instead make use of the solution to these equations, as in (5.5) and (6.11), for the overall impact of changes in government funding per pupil for individual schools on school examination results, together with the first-order conditions for each school $\ell \, \varepsilon \Omega$:

$$\sum_{\tau=1}^{r} q_\tau^{-\varsigma} (\delta q_\tau / \delta R_\ell) = \lambda n \quad (7.2)$$

where λ is the Lagrangean multiplier associated with the aggregate budget constraint in (7.1). Equations (A9), (5.4), (5.5), (6.10), (7.1) and (7.2) imply that the optimal budget share for each school ℓ ε Ω equals:

$$s_\ell \equiv (nR_\ell^* / R_T) = \phi_o + \phi_1 (q_\ell^{1-\varsigma} /((1-\varsigma)W) \text{ where } \phi_o \equiv \varphi_1 / r(\gamma_1 + \varphi_1) < 0, \phi_1 \equiv \gamma_1 /(\gamma_1 + \varphi_1) > 0 \quad (7.3)$$

so that the government educational budget share of each school ℓ ε Ω in (7.3), if set optimally, would increase linearly with the proportionate extent to which the school's educational performance contributes to the overall welfare function W, after taking into account the policy-maker's inequality aversion coefficient ς. From (7.3), we have for each school ℓ ε Ω:

$$\partial s_\ell / \partial q_\ell > 0 \ \textit{for} \ \varsigma < 1, \ \partial s_\ell / \partial q_\ell = 0 \ \textit{for} \ \varsigma = 1, \ \partial s_\ell / \partial q_\ell < 0 \ \textit{for} \ \varsigma > 1 \quad (7.4)$$

so that each school's optimal share of the government educational budget is an increasing, decreasing or constant function of its examination performance, according to whether the inequality aversion coefficient ς is less than, greater than or equal to one. In addition from (7.3):

$$s_\ell = 1/r \ \textit{for} \ \varsigma = 1 \ \textit{or} \ q_\ell^{1-\varsigma} = q^o \equiv (\sum_{\tau=1}^{r} q_\tau^{1-\varsigma} / r), s_\ell > 1/r \ \textit{for} \ q_\ell^{1-\varsigma} > q^o, s_\ell < 1/r \ \textit{for} \ q_\ell^{1-\varsigma} < q^o \ (7.5)$$

so that the optimal school budget shares are all equal to 1/r if ς equals one, but otherwise a school's optimal budget share will exceed, equal or fall short of 1/r depending upon whether its level of educational attainment exceeds, equals or falls short of the overall mean level q^o of the educational attainment, after adjustment by the coefficient of inequality aversion. If the policy-maker's concern for inequality is sufficiently great that $\varsigma > 1$, (7.5) implies that those schools with relatively low levels of educational attainment will be allocated a greater share of the government educational budget than those with higher levels of attainment. However, if $\varsigma < 1$, a greater policy emphasis is placed upon boosting the overall mean level of educational performance, with (7.5) implying that those schools that have shown themselves capable of relatively high levels of educational attainment are allocated a greater share of the government educational budget under the optimal resource allocation rule given by (7.3).

Under the optimal resource allocation formula, the proportional impact on the government's welfare function, W, of a unit proportionate increase in its schools budget, R_T, will equal:

$$\varepsilon_W \equiv (dW / dR_T)(R_T / W) = \lambda(R_T / W) = \gamma_1 + \varphi_1 = \varepsilon > 0 \qquad (7.6)$$

using (5.4) – (5.6), (6.9)-(6.10) and (7.1)–(7.3). The magnitude of the external competitive effects that reduce the value of ε below the weighted sum in (6.10) of the direct effects on individual schools of additional resources will itself depend upon a number of features of educational policy that influence the magnitude of the relevant coefficients in equations (2.3), (3.11), (4.6) and (4.7). These features include the extent to which: i. individual teachers' careers are enhanced by being associated with schools with high levels of educational attainment in absolute terms, rather than with schools that may have high levels of *value added*, after allowing for educational disadvantage and low levels of pupil prior attainment; ii. entry to schools is dependent upon residence in local residential catchment areas, rather than upon selection from a wider spectrum of socio-economic locations in the way suggested by the ‘banding’ proposals in DfES (2005, p.47) for achieving ‘an all-ability intake’; iii. there is selection by parental interview or other proxies that ensure that schools with higher initial levels of educational attainment succeed in recruiting pupils from more advantaged backgrounds; iv. schools are under strong pressure to appear high in national league tables of examination results; and v. schools have greater freedom to determine their own admissions policy, as suggested in DfES (2005, pp. 46 – 7). Each of these factors will influence the extent to which competition in the housing market, and in the labour market for teachers, will lead to positive feedback effects where initially advantaged schools secure greater cumulative advantages that further boost their levels of educational attainment, albeit with negative external effects on the relative competitive position of other schools in these markets.

8 CONCLUSION

The introduction of competition, for teachers and for school places, into the analysis of the impact of resources on educational outcomes highlights the powerful influence which resources can have on the *distribution* of educational outcomes, once a more extensive general equilibrium approach is introduced into the analysis than the earlier concentration upon the educational production function allows. Resource allocation policies, and associated funding formulae, may then be derived which optimise the distribution of educational resources across schools for any given degree of aversion to inequality in educational attainment, in the presence of the cumulative effects on educational attainment which such competition entails.

APPENDIX

(5.1) may be written in the form:

$$\text{YB = - ZC + U where } Y \equiv [y'_{\ell k}],\ B \equiv [b_{kj}], Z \equiv [z_{\ell g}], C \equiv [c_{gj}], U \equiv [u_{\ell j}] \qquad \text{(A1)}$$

Differentiation of (2.3), (4.6) and (4.7) implies:

$$[d\bar{y}_k]B_o = [\,0, 0, -dR'', -dR''] \text{ where } B_o \equiv [b_{kj}] \ for\ k, j = 1, 3, 4, 5 \qquad \text{(A2)}$$

$$B_o = \begin{bmatrix} B_{o11} & 0 \\ B_{o21} & -I \end{bmatrix} \text{ where } B_{o11} \equiv [b_{kj}] \ for\ k, j = 1, 3 \text{ and } B_{o21} \equiv [b_{kj}] \ for\ k = 4, 5;\ j = 1, 3 \qquad \text{(A3)}$$

$$B = \begin{bmatrix} B_{11} & 0 \\ B_{21} & -I \end{bmatrix} \text{ where } B_{11} \equiv [b_{kj}] \ for\ k, j = 1, 2, 3 \text{ and } B_{21} \equiv [b_{kj}] \ for\ k = 4, 5;\ j = 1, 2, 3 \qquad \text{(A4)}$$

$$\text{Hence} \quad [D^o_{kj}] \equiv B_o^{-1} = \begin{bmatrix} B_{o11}^{-1} & 0 \\ B_{o21}B_{o11}^{-1} & -I \end{bmatrix},\ [D_{kj}] \equiv B^{-1} = \begin{bmatrix} B_{11}^{-1} & 0 \\ B_{21}B_{11}^{-1} & -I \end{bmatrix} \qquad \text{(A5)}$$

We will assume that B is a Hicksian stable matrix, with principal minors that alternate in sign. Hence so too are B_{11}, B_o and B_{o11}. Since in (2.3), (3.11) and (4.6) we have $b_{kj} > 0$ for $k \neq j$ and $b_{kk} = -1 < 0$ for all k, j = 1, 2, 3, we may write $B_{11} = M - I$ and $B_{o11} = M_o - I$, where M and M_o are indecomposable non-negative matrices with zero diagonal elements, and I is an identity matrix. It follows from Quirk and Saposnik (1968, pp. 210-11) that all the elements of the inverses $B_{11}^{-1} \equiv [D_{kj}]$ for k, j = 1, 2, 3 and $B_{o11}^{-1} \equiv [D^o_{kj}]$ for k, j = 1, 3 are negative. Since, from (2.3), (3.11), (4.6), (4.7), (A3) and (A4), all the elements of Bo_{21} and B_{21} are positive, this in turn implies from (A5) that for k = 4, 5: $D^o_{kj} < 0$ for $j = 1, 3$ and $D_{kj} < 0$ for j = 1,2,3, $-D^o_{kj} = -D_{kj} = \delta_{kj}$, the Kronecker delta, for j = 4, 5. Hence from (A2) and (A5):

$$d\bar{y}_k / dR'' = -(D^o_{4k} + D^o_{5k}) > 0 \quad \text{for } k = 1, 3, 4, 5 \tag{A6}$$

Eqns (2.3), (3.11), (4.6), (4.7) and (5.1) imply for each ℓε Ω:

$$[dy'_{\ell k}]B = [0, 0, 0, -dR'_\ell, -dR'_\ell] \quad \text{for } k = 1, \ldots, 5 \tag{A7}$$

$$[dy_{\ell k}]B = [0, \sum_{h=1,3}^{5} d\bar{y}_h b_{h2}, 0, -d \ln R_\ell, -d \ln R_\ell] \quad \text{for } k = 1, \ldots, 5 \tag{A8}$$

with $d\bar{y}_2 = 0$, since $\bar{y}_2 = \mu_Y =$ constant. (A5) and (A7) imply, holding all other R'_h constant:

$$(\delta y'_{\ell k} / \delta R'_\ell) = \gamma_k \equiv -(D_{4k} + D_{5k}) > 0 \text{ for } k = 1, \ldots, 5 \tag{A9}$$

(A5), (A6), (A8) – (A9) imply, holding all other R_h constant, that:

$$(\delta y_{\ell k} / \delta \ln R_\ell) = \gamma_k + \sum_{h=1,3}^{5} (d\bar{y}_h / dR'')(\delta R'' / \delta \ln R_\ell) b_{h2} D_{2k} \tag{A10}$$

$$= (\delta y'_{\ell k} / \delta R'_\ell) - \sum_{h=1,3}^{5} (D^o_{4h} + D^o_{5h}) b_{h2} D_{2k} / r \; < \; (\delta y'_{\ell k} / \delta R'_\ell) \tag{A11}$$

where each $D^o_{4h} < 0, D^o_{5h} < 0, D_{2k} < 0, b_{h2} > 0$ from above, and where from (A9):

$$\varepsilon''_\ell \equiv (\delta y'_{\ell 1} / \delta R'_\ell) = \delta(\ln q_\ell - \bar{y}_1) / \delta(\ln R_\ell - R'') = (\delta q^o_\ell / q^o_\ell) / (\delta R^o_\ell / R^o_\ell) > 0 \tag{A12}$$

$$\text{for } q^o_\ell \equiv q_\ell / q^m, \; q^m \equiv \prod_h q_h^{1/r}, \; R^o_\ell \equiv R_\ell / R^m, \; R^m \equiv \prod_h R_h^{1/r} \tag{A13}$$

REFERENCES

Aitchison, J. and Brown, J. (1963). *Lognormal Distribution in Economics,* Cambridge, Cambridge University Press.

Atkinson, A. (1970). 'On the Measurement of Inequality', *Journal of Economic Theory*, Vol. 2, pp. 244-263.

Black, S. (1999). 'Do Better Schools Matter? Parental Valuation of Elementary Education', *Quarterly Journal of Economics* , Vol.114, pp. 577-599.

Bradley, S., Crouchley, R., Millington, J. and Taylor, J. (2000). 'Testing for Quasi-market Forces in Secondary Education', *Oxford Bulletin of Economics and Statistics*, Vol. 62, pp. 357 – 390.

Bradley, S. and Taylor, J. (2002). 'The Effect of the Quasi-market on the Efficiency-Equity Trade-off in the Secondary School Sector', *Bulletin of Economic Research*, Vol. 54, pp. 295-314.

Brasington, D. (1999). 'Which Measures of School Quality Does the Housing Market Measure?' *Journal of Real Estate Research* , Vol.18, pp. 395-413.

Cheshire, P. and Sheppard, S. (1998). ‘Estimating the Demand for Housing, Land and Neighbourhood Characteristics’, *Oxford Bulletin of Economics and Statistics* , Vol. 60, pp. 357–382.

Coleman, J. (1966). *Equality of Educational Opportunity*, Washington, D.C., Office of Education.

Coulthard, M. and Kyriacou, C. (2002). ‘Does Teaching as a Career Offer What Students are Looking For?’, in Menter, I., Hutchings, M. and Ross, A. (eds.), *The Crisis in Teacher Supply*, Stoke, Trentham, pp. 29-58.

Cuckle, P. and Broadhead, P. (1999). Effect of Ofsted Inspection on School Development and Staff Morale, in Cullingford, C. (ed.), pp. 176-187.

Cullingford, C. (ed.) (1999). *An Inspector Calls: OFSTED and its Effect on School Standards*, London, Kogan Page.

Davidson, R. and MacKinnon, J. (2004). *Econometric Theory and Methods*, Oxford, Oxford University Press.

Department for Education and Skills (2005). *Higher Standards, Better Schools for All, Cm 6677*. London, HMSO.

Dolton, P. (1990). ‘The Economics of UK Teacher Supply: The Graduate’s Decision’, *Economic Journal*, Vol. 100, pp. 91-104.

Dolton, P. and van der Klaauw, W. (1995). ‘Leaving Teaching in the UK: A Duration Analysis’, *Economic Journal* , Vol.105, pp. 431-44.

Ermisch, J. and Francesconi, M. (2001). ‘Family Matters: Impacts of Family Background on Educational Attainments’, *Economica*, Vol. 68, pp. 137-156.

Freeman, A.M. (1979). ‘Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues’, *Scandanavian Journal of Economics*, Vol. 81, pp. 154 – 173.

Hanushek, E. (1986). ‘The Economics of Schooling: Production and Efficiency in Public Schools’, *Journal of Economic Literature*, Vol. 24, pp. 1141-1177.

Hanushek, E. (1997). ‘Assessing the Effects of School Resources in Student Performance: An Update’, *Educational Evaluation and Policy Analysis*, Vol. 19, pp. 141-164.

Hanushek, E., Rivkin, S. and Taylor, L. (1996). ‘Aggregation and the Estimated Effects of School Resources’, *Review of Economics and Statistics*, Vol. 78, pp. 611 - 627.

Haurin, D. and Brasington, D. (1996). 'School Quality and Real House Prices: Inter- and Intra-Metropolitan Effects', *Journal of Housing Economics*, Vol. 5, pp. 351-368.

Haveman, R. and Wolfe, B. (1995). 'The Determinants of Children's Attainments: A Review of Methods and Findings', *Journal of Economic Literature*, Vol. 33, pp. 1829-1878.

Krueger, A. (1999) 'Experimental Estimates of Education Production Functions', *Quarterly Journal of Economics*, Vol. 114, pp. 497-532.

Ladd, H. and Walsh, R. (2002). 'Implementing Value-Added Measures of School Effectiveness: Getting the Incentives Right', *Economics of Education Review*, Vol. 21, pp. 1-17.

Law, S. and Glover, D. (1999). 'Does Ofsted Make a Difference? Inspection Issues and Socially Deprived Schools', in Cullingford, C. (ed.), pp. 148 -166.

Le Grand, J. and Bartlett, W. (1993). *Quasi-Markets and Social Policy*, Basingstoke, Macmillan Press.

Lee, J.-W. and Barro, R. (2001). 'Schooling Quality in a Cross-Section of Countries', *Economica*, Vol. 68, pp. 465-488.

Leech, D. and Campos, E. (2001). 'Is Comprehensive Education Really Free? A Case Study of the Effects of Secondary School Admissions Policies on House Prices in One Local Area', *Warwick Economic Research Paper 581*.

Lipsey, R. and Lancaster, K. (1956). 'The General Theory of Second Best', *Review of Economic Studies*, Vol. 24, pp. 11–32.

Mayston, D. (2005). 'Structural Determinants of Cumulative Endogeneity Bias', *University of York Discussion Papers in Economics 05/11*, http://www.york.ac.uk/depts/econ/dp/2005.htm

Menter, I., Hutchings, M. and Ross, A. (eds.) (2002). *The Crisis in Teacher Supply*, Stoke, Trentham.

Murdane, R. (1996). 'Staffing the Nation's Schools with Skilled Teachers', in Hanushek, E. and Jorgenson, D. (eds.), *Improving America's Schools: The Role of Incentives*, Washington DC, National Academy Press, pp. 241-258.

Oates, W. (1969). 'The Effect of Property Taxes and Local Spending on Property Values: An Emprical Study of Tax Capitalization and the Tiebout Hypothesis', *Journal of Political Economy*, Vol. 77, pp. 957-971.

Quirk, J. and Saposnik, R. (1968). *Introduction to General Equilibrium Theory and Welfare Economics*, New York, McGraw-Hill.

Reid, I. and Caudwell, J. (1997). 'Why Did Secondary PGCE Students Choose Teaching as a Career?', *Research in Education*, Vol. 58, pp. 46-58.

Rosen, S. (1974). 'Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition', *Journal of Political Economy*, Vol. 82, pp. 34-55.

Ross, S. and Yinger, J. (1999). 'Sorting and Voting: A Review of the Literature on Urban Public Finance', in Cheshire, P. and Mills, E. (eds.), *Handbook of Regional and Urban Economics,* Vol. 3, Amsterdam, North-Holland, pp. 2001–2060.

Rutter, M.., Maughan, B., Mortimore, P. and Ouston, J. (1979). *Fifteen Thousand Hours: Secondary Schools and their Effects on Children*, London, Open Books.

Sheppard, S. (1999). 'Hedonic Analysis of Housing Markets', in Cheshire, P., and Mills, E. (eds.), *Handbook of Regional and Urban Economics*, Vol. 3, Amsterdam, North-Holland, pp. 1595–1635.

Smithers, A. and Robinson, P. (2003). *Factors Affecting Teachers' Decisions to Leave the Profession*, DfES Research Report RR430, London, Department for Education and Skills.

Smithers, A. and Robinson, P. (2004). *Teacher Turnover, Wastage and Destinations*. DfES Research Report RR553, London, Department for Education and Skills.

Smithers, A. and Robinson, P. (2005). *Teacher Turnover, Wastage and Movements Between Schools*. DfES Research Report RR640, London, Department for Education and Skills.

Summers, A. and Wolfe, B. (1997). 'Do Schools Make a Difference?', *American Economic Review*, Vol. 67, pp. 639-652.

Treasury, H.M. (2004). *2004 Spending Review: New Public Spending Plans 2005-2008, Cm 6237*, London, H.M. Treasury.

Winkler, D. (1975). 'Educational Achievement and School Peer Group Composition', *Journal of Human Resources*, Vol.10, pp. 189-204.

Yinger, J. (1982). 'Capitalisation and the Theory of Local Public Finance', *Journal of Political Economy*, Vol. 90, pp. 917-943.