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The Value of State Education to Consumers

Sofia N. Andreou, Panos Pashardes and Nicoletta Pashourtidou

Department of Economics, University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus
Tel.: +357-22893700, Fax: +357-22895028, Web site: http://www.ucy.ac.cy/econ/en

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Sofia N. Andreou*

Department of Economics, University of Cyprus

Panos Pashardes

Department of Economics, University of Cyprus

Nicoletta Pashourtidou

Economics Research Centre, University of Cyprus

Abstract

This paper considers the value of state schooling, as perceived by consumers, taking into account that many households supplement the minimum education provided free of charge with out-of-pocket payments through acquiring accommodation in the catchment area of a high quality state school. It suggests ways to circumvent difficulties in modelling household behaviour arising from joint housing-education consumption in the context of a two-stage demand system, where the proposed money-metric of state schooling can be estimated from data readily available in household expenditure surveys. The empirical analysis, based on UK data, estimates this money metric as the amount households with school-age children would be willing to accept in order to opt out of the state education system. The efficiency and distributional implications of the empirical findings are discussed.

JEL Classification: D11, H42, I21

Keywords: Consumer Demand Analysis, Valuation of State Education, UK data

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* Corresponding author: Department of Economics, University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus, email: andreou.sofia@ucy.ac.cy.

1. Introduction

The measurement of the value of publicly provided private goods - such as education, health care, transport and housing - to the recipient is essential for assessing the efficiency of state production as well as the impact of state intervention on household welfare, income distribution and poverty. This paper proposes a consumer demand approach to evaluating household utility from a publicly provided private good that can be supplemented with out-of-pocket payments. Education is the commodity of interest in the paper; however, the proposed theoretical and empirical methods can also be used to investigate other publicly provided private goods mentioned above.

The free of charge provision of a minimum level of education by the state is a world-wide phenomenon, based on both efficiency (positive externalities) and equity (less income inequality) criteria (Epple and Romano, 1996; Blomquist and Christiansen, 1995, 1999; Levy, 2005; Gahvari and Mattos, 2007). There is an extensive literature examining a wide range of different issues concerning this provision, such as finding the optimal private-public mix (De La Croix and Doepke, 2009), the public spending and individual school choice (Cohen-Zada and Justman, 2003), the majority voting based funding of public education (Bearse et al., 2005) and the effects of sorting by income and age on educational inequality (Epple et al, 2012). The question of how consumers perceive the benefit of free of charge state education, however, has not received enough attention in the literature, in spite that during the past decades there has been a strong debate about the ability of the state to provide quality education (e.g. Ladd, 1992; Epple and Romaro 1998; Neshyba, 1999, 2000).

Most studies aimed at estimating the value consumers attribute to state education using contingent valuation surveys to assess willingness to pay for this education (Brookshire and Coursey, 1987; Clinch and Murphy, 2001; Hanemann, 1994); or hedonic analysis (Rosen, 1974) to estimate the effect of academic performance on house prices in the school's catchment area (e.g. Black, 1999; Clapp et al., 2008; Fack and Grenet, 2010; Black and Machin, 2011). Empirical estimates of willingness to pay obtained from contingent valuation studies, however, are specific to the design and conduct of an ad hoc survey. At best, hedonic analysis can only yield a money-metric of better quality state schooling and not a money-metric of consumers' utility from a freely provided state education. To our knowledge, the only recent study aimed at estimating such a metric is Aaberge et al. (2010). However, this study investigates the spending behaviour of local government rather than that of consumers, as in this paper; consequently,

empirical implementation of the Aaberge et al. (2010) model requires combination of data from different sources, including administrative data that may not be available in many countries.

This paper proposes a method to estimate the value of state education as perceived by those consuming it and defined by a money-metric that reflects the amount households are willing to accept in order to opt out of the state education system. Furthermore, the proposed method also accounts for the fact that households supplement the free of charge state education with out-of-pocket payments through locating themselves in the catchment area of high quality state schools. These tasks are accomplished in the context of a model that satisfies the consumer theory fundamentals and can be estimated empirically using household survey data routinely available in many countries. More specifically, it uses the Quadratic Logarithmic Almost Ideal Demand System (QUAIDS) functional form proposed by Banks et al. (1997), which belongs to the family of Rank-3 demand systems, the most general empirical representation of consumer preferences satisfying integrability, i.e. recovery of the parameters of the indirect utility function from empirical demand analysis (Gorman, 1981; Lewbel, 1991). Integrability is mandatory in the context of the analysis in this paper because the proposed metric of the welfare stemming from the consumption of state education is constructed from parameter estimates obtained from a complete demand system. The empirical analysis is based on individual household data drawn from the UK 2001-2012 Living Costs and Food Survey (LCF). Notably, a substantial part of the empirical modelling and estimation addresses data problems, mainly those arising from the fact that an element of the housing expenditure in the data represents supplementary expenditure on education, insofar as it represents a premium paid for purchasing a house in the catchment area of high performing state schools.

The estimated money-metric of households willingness to opt out of state education can be used to examine efficiency aspects of public provision by: (a) comparing the cost of state education perceived by consumers with the actual production cost of this provision; and (b) accounting for the fact that the true cost of education may be higher than that registered in the data, because the out-of-pocket payment for purchasing a house in the catchment area of a high performing state school is considered as housing rather than education expenditure. The analysis in the paper can also be used to examine distributional aspects of education vis-à-vis the ability of households to use out-of-pocket payments in order to acquire access to better quality education for their children. These and other theoretical and empirical results in the paper (i.e. the opting

for exclusively private schooling when supplementation cannot meet the education requirements of the household) can guide policies towards a more informed and constructive analysis of the role which can be played by the state and private education sectors; notwithstanding, of course, positive externality and social policy aspects of education, at large.

The next section considers consumer behaviour under the options of supplementing or replacing state with private education with a view to constructing a money-metric of the value of state education. Section 3 reports the results obtained by the empirical application of the model to UK data; and Section 4 concludes.

2. Consumer demand for education

This section considers consumer behaviour when state education is provided free of charge at some minimum quality. Those not satisfied with this quality of education can either (i) opt out of the state education system altogether and send their children in private schools, in which case they pay fees; or (ii) supplement the free of charge minimum state education by purchasing relatively more expensive accommodation in the catchment area of a better quality state school. First, we present these options using diagrams and then model their effect on consumer behaviour in the context of an integrable complete demand system. Subsequently, we consider how a money-metric of utility from freely provided state education can be constructed.

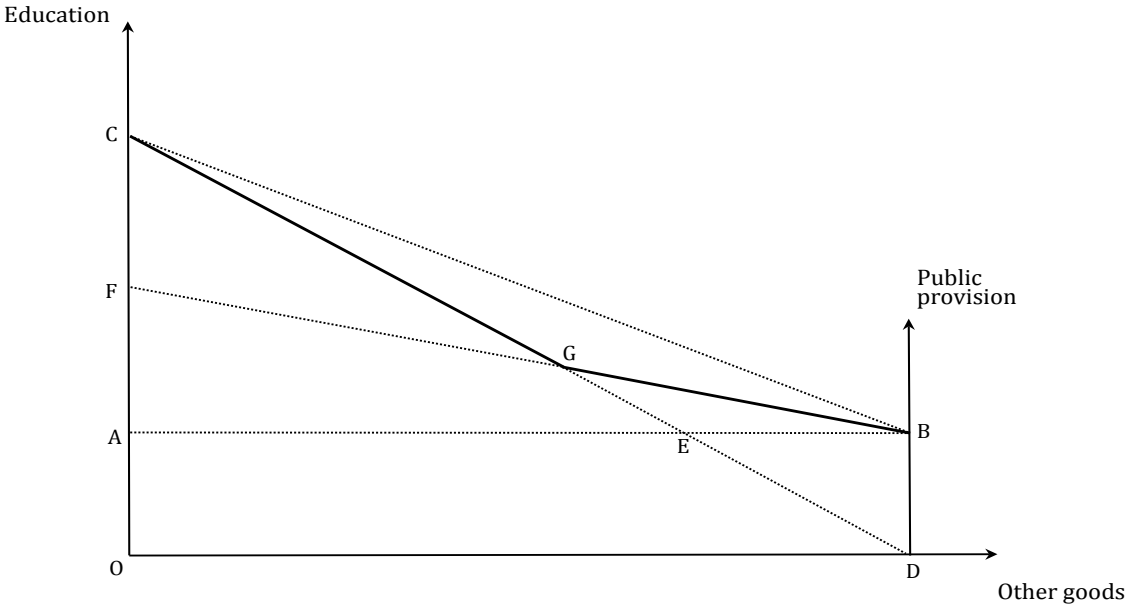
2.1 Diagrammatic exposition

Consumer behaviour in a regime where the free provision of a private good can be supplemented with out-of-pocket purchases is illustrated diagrammatically in Figures 1 and 2, where the vertical axis measures the consumption of the good in question, here education, and the horizontal axis the consumption of other goods.

The first of the two figures shows the budget constraint when consumers can obtain a fixed quantity of education free of charge, represented by the distance OA in the diagram. In this case a consumer with a budget line CD would trade other goods for education in the free market along the segment CE of this line only, because the quantity of education consumed along the segment ED is below the level which can be obtained free of charge. Furthermore, for consumers able to supplement the freely provided (quantity OA) with paid education the actual budget line should start from point B and

be above the free state provision represented by the horizontal segment EB; but cannot cross the vertical axis above C because the free state provision cannot be consumed simultaneously with the maximum level of education which can be purchased from the private sector, i.e. attend both state and private full-time education. Indeed, the budget line CB is the locus of 'optimum' supplementation points, in the sense that the sum of the freely provided and purchased education is as much as one can obtain from the private sector by opting completely out (and losing the benefit) of free state education. In practice, however, this case is very unlikely due to attendance constraints and/or the higher unit cost of education purchased in small quantities (e.g. private tuition outside school hours). After all, if CB were the actual budget line, then no full-time private education could be observed as all the points along the CE budget line are dominated (correspond to lower quantities of both education and other goods) by the perfect supplementation line CB.

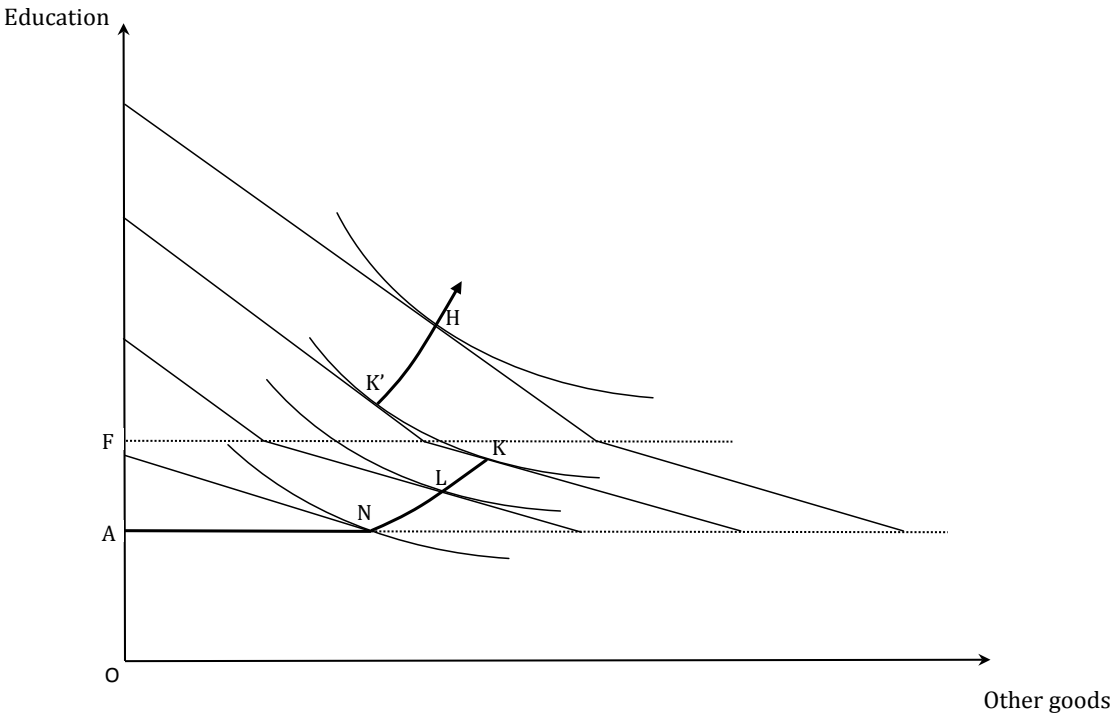
Figure 1: Budget constraint



It follows from the analysis above that in a situation where a consumer can supplement free state with purchased education the budget line should start from point B and have a smaller (in absolute terms) negative slope than the CB line. Such line is BF in Figure 1. Again, only the segment GB of this budget line is relevant (the points along the GF segment are sub-optimal) so that the budget constraint is given by the kinked line BGC. In Figure 2 we put the budget constraint and indifference curves on the same diagram to derive demand for education. In this diagram, the expansion path is both kinked and

discontinued. Thus, (i) below point N consumers have expansion path AN, consuming only the quantity of education freely provided by the state, OA; (i) above N and up to K they follow the expansion path NLK, supplementing the minimum level of state education through paying a premium to secure accommodation in the catchment area of a high performing state school, thereby increasing the consumption of education up to OF; and (iii) above K′ they follow the expansion path K′H, along which all education consumed is purchased from the private sector. It should be noted that the equilibrium points K′ and K in Figure 2 correspond to the same level of utility, i.e. the consumer is indifferent between completely opting out of the state system (purchase all education from the private sector) and supplementing free state education with out-of-pocket purchases of education from the private sector.

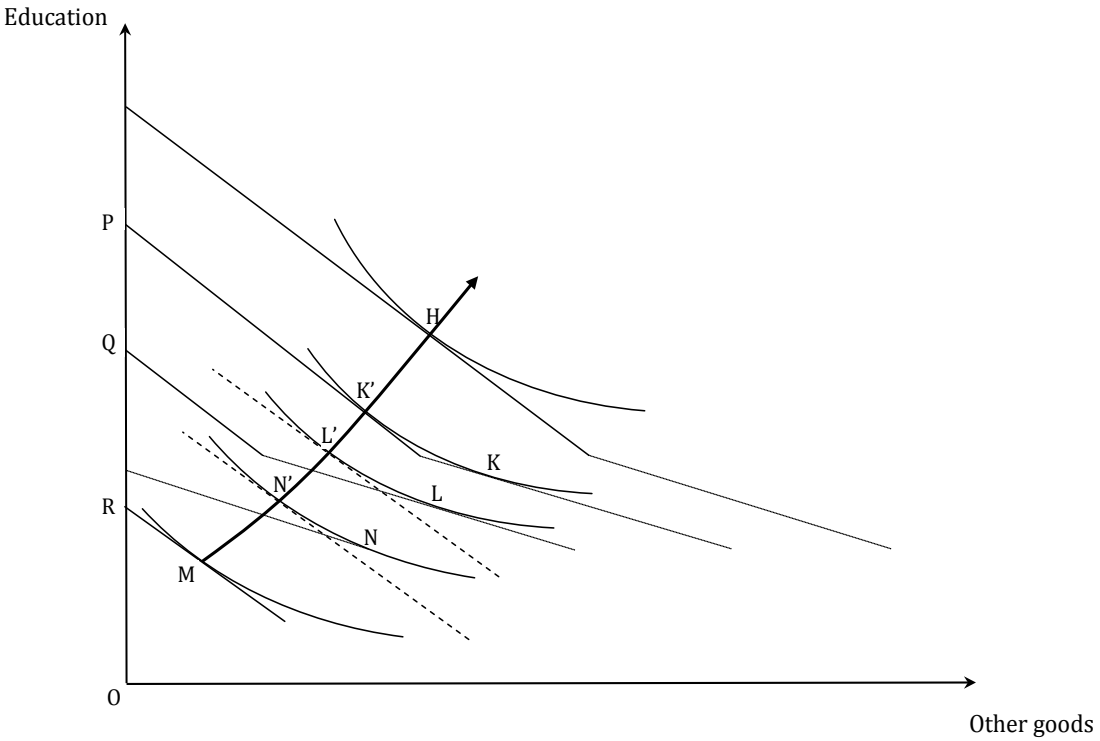
Figure 2: Demand for education



Suppose now that the freely provided state education is withdrawn and all education is purchased from the private sector alone, as shown in the diagram of Figure 3. As one would expect the consumers affected in this scenario are those with a budget below PK′, i.e. those who have not already opted out of the state education system. Furthermore, the loss of utility is shown to decrease with the level of supplementation. For example, consumers at point L would require compensation equal to the difference between the

(dotted) budget line going through point L´ and the (solid) budget line going through point Q to be at the same utility level with and without free of charge state education. The corresponding compensation for consumers at point N, consuming only the minimum state education, would be equal to the difference between the (dotted) budget line going through point N´ and the (solid) budget line going through point R (and M).[1]

Figure 3: Money metric of free provision



2.2 Complete consumer demand system

The diagrammatic exposition in the previous sub-section shows how a freely provided private good can be supplemented with out-of-pocket purchases in the market. In the case of education in the UK this is effected through paying a premium to acquire accommodation in the catchment area of a high performing state school. Thus, education and housing expenditure cannot be observed separately, except for households with children in full-time private education. To circumvent this problem here we adopt the standard assumption that household consumption decisions can be separated into stages: first total expenditure is allocated to broad commodity groups, such as non-durables and durables; then the group expenditure is allocated to commodities in the

[1] Thus, the diagram in Figure 3 illustrates the progressivity effects of the free of charge provision of low quality goods by the state, (Besley and Coate, 1991).

group. Furthermore, we consider education to be in the category of goods decided at the upper budgeting stage, the rational being that it is a commodity purchased (along with housing) with a long consumption horizon. For instance, by deciding to supplement the freely provided minimum state education through purchasing a house in the catchment area of a high performing school consumers undertake a long-term spending commitment. As in the case of purchasing a durable good, consumption is 'locked' at a given level that can be too costly to alter in response to changes in current income or prices.

Furthermore, demand analysis here considers the two budgeting stages described above to be implicitly separable (Gorman 1981; Blackorby and Shorrocks, 1996;), i.e. the group g cost function is defined on the group price vector $p_g = (p_{g1}, \dots, p_{gn})'$ and total utility U.[2] Thus, utility is common to both upper and lower stage cost functions and provides a connection between decisions taken at different budgeting stages: higher (lower) consumption cost in the second budgeting stage are transmitted to the first budgeting stage effects through lower (higher) total utility; and vice versa. Below we describe how this connection in spending at different budgeting stages (not found, for example, in weak separability, where not only prices but utility is also defined at commodity group level) can be exploited to construct a money-metric of utility derived from consuming the free (minimum) state education.

Under implicit separability the cost function describing consumer's preferences can be written as

$$C(p, U) = C\left[c_1\left(p_{11,\dots\dots,}p_{1n,}U\right), \dots\dots, c_G\left(p_{G1,\dots\dots,}p_{Gm,}U\right), U\right], \qquad (1)$$

where $c_g(.)$ is the sub-function reflecting the unit cost (composite price) of the g^{th} commodity group $q_g = (q_{g1,\dots\dots,}q_{gn})'$; the subscripts n and m indicate the number of goods.

Consumer demand for the i^{th} good in the g^{th} group is obtained by applying Shepherd's lemma to (1),

$$q_{gi} = \frac{\partial C(.)}{\partial p_{gi}} = \frac{\partial C(.)}{\partial c_g(.)}\frac{\partial c_g(.)}{\partial p_{gi}} \qquad (2)$$

[2] In contrast, the more popular concept of weak separability implies that the group sub-cost functions are defined on group sub-utility (Deaton and Muellbauer, 1980).

where $\partial c_g(.)/\partial p_{gi}$ is the Hicksian consumer demand for the i^{th} good in the g^{th} group conditional on the (Hicksian) demand for the g^{th} commodity group given by $\partial C(.)/\partial c_g(.)$.

Writing (2) in the form

$$q_{gi} = \frac{\partial \ln c(.)}{\partial \ln c_g(.)} \frac{C(.)}{c_g(.)} \frac{\partial \ln c_g(.)}{\partial \ln p_{gi}} \frac{c_g(.)}{p_{gi}}, \tag{3}$$

yields the Hicksian consumer demand for the i^{th} good in the g^{th} commodity group as share in total expenditure $X = \sum_g x_g$,

$$\omega_{gi}^{*} \equiv \frac{q_{gi}\, p_{gi}}{X} = \frac{\partial \ln C(.)}{\partial \ln c_g(.)} \frac{\partial \ln c_g(.)}{\partial \ln p_{gi}}, \tag{4}$$

where $\partial \ln c_g\,(.)/\partial \ln p_{gi}$ is the share of the i^{th} good in the g^{th} group expenditure, $\omega_{gi} \equiv q_{gi}\; p_{gi}/x_g$; and $\partial \ln C(.)/\partial \ln c_g(.)$ the share of the g^{th} group in total expenditure, $\omega_g \equiv q_g(.)\, p_g/X$.

We assume consumer preferences to be described by the Quadratic Logarithmic cost function (Lewbel 1990)[3]. At the first budgeting stage this function is written as

$$\ln C(p, U) = A(c) + \frac{B(c)\, U}{1 - \Lambda(c) U} \tag{5}$$

where $A(c)$, $B(c)$ and $\Lambda(c)$ are linearly independent and homogeneous functions. Demands for commodity groups as shares in total expenditure are then written as

$$\omega_g = A_g(c) + B_g(c) \left[\frac{U}{1 - \Lambda(c) U}\right] + \Lambda_g(c) B(c) \left[\frac{U}{1 - \Lambda(c) U}\right]^2, \tag{6}$$

where c is the vector of group prices $c_1, \ldots, c_G$ and $A_g(c) = \partial A(c)/\partial c_g$, $B_g(c) = \partial B(c)/\partial c_g$ and $\Lambda_g(c) = \partial \Lambda(c)/\partial c_g$.

Similarly, the sub-function reflecting the unit cost of consumption of the g^{th} commodity group is given by

[3] The QUAIDS model belongs to the family of rank-3 demand systems, the most general empirical representation of consumer preferences that satisfies integrability (the ability to recover the parameters of the indirect utility function from empirical demand analysis; Gorman 1981 and Lewbel 1991).

$$\ln c_g(p_g,U) = \alpha(p_g) + \frac{\beta(p_g)U}{1-\lambda(p_g)U} \tag{7}$$

where $\alpha(p_g), \beta(p_g)$ and $\lambda(p_g)$ are, also, linearly independent and homogeneous functions and the second stage demand for the i^{th} commodity as share in the g^{th} group expenditure has the form

$$\omega_{gi} = \alpha_{gi}(p_g) + \beta_{gi}(p_g)\left[\frac{U}{1-\lambda(p_g)U}\right] + \lambda_{gi}(p_g)\beta(p_g)\left[\frac{U}{1-\lambda(p_g)U}\right]^2 \tag{8}$$

where $\alpha_{gi}(p_g) = \partial\alpha(p_g)/\partial p_{gi}$, $\beta_{gi}(p_g) = \partial\beta(p_g)/\partial p_{gi}$ and $\lambda_{gi}(p_g) = \partial\lambda(p_g)/\partial p_{gi}$.

By assumption (implicit separability) utility is defined at the first budgeting stage only. Therefore, using (5) we can obtain the first and second stage Marshallian demands

$$\omega_g = A_g(c) + \frac{B_g(c)}{B(c)}[\ln X - A(c)] + \frac{\Lambda_g(c)}{B(c)}[\ln X - A(c)]^2 \tag{9}$$

and

$$\omega_{gi} = \alpha_{gi}(p_g) + \beta_{gi}(p_g)\left[\frac{1}{\left(\frac{\ln X - A(c)}{B(c)}\right)^{-1} + \Lambda(c) - \lambda(p_g)}\right] + \lambda_{gi}(p_g)\beta(p_g)\left[\frac{1}{\left(\frac{\ln X - A(c)}{B(c)}\right)^{-1} + \Lambda(c) - \lambda(p_g)}\right]^2, \tag{10}$$

respectively. Thus, the second stage demand (10) is affected by group prices c_g, all $g = 1 \ldots G$, through utility only.

In order to simplify (10) for more convenient empirical application, we consider the role played by the price indices $A(c)$, $B(c)$ and $\Lambda(c)$ in the context of (5): the first shows the change in subsistence (zero utility) cost from a change in the level of group prices; while the second shows how this change in cost is modified and the third how this modification varies as utility increases. Thus, $B(c)$ captures the effects of inflation at different utility levels (e.g. inflation bias against the poor due to necessities increasing faster in price than luxuries); while $\Lambda(c)$ captures *changes* in the effects of inflation at different utility levels (e.g. relatively more inflation bias against households at middle utility). A similar role is played by the group price indices $\alpha(p_g), \beta(p_g)$ and $\lambda(p_g)$ at the

lower budgeting stage. Therefore, when the effect of price changes on cost varies with utility (i.e. when price changes are correlated with the budget elasticities of goods), but this effect is constant over time, one can use the approximations $\Lambda(c) \simeq \lambda(p_g) \simeq 1$ to simplify (10) to

$$\omega_{gi} = \alpha_{gi}(p_g) + \frac{\beta_{gi}(p_g)}{B(c)}[\ln X - A(c)] + \frac{\lambda_{gi}(p_g)\beta(p_g)}{B(c)^2}[\ln X - A(c)]^2 \qquad (11)$$

Furthermore, if the approximation $B(c) \simeq \beta(p_g) \simeq 1$ is also adopted, i.e. the price changes are assumed to have the same effect on cost at all utility levels (price changes are not correlated with the budget elasticities of goods), then (10) simplifies to a system of budget share equations

$$\omega_{gi} = \alpha_{gi}(p_g) + \beta_{gi}(p_g)[\ln X - A(c)] + \lambda_{gi}(p_g)[\ln X - A(c)]^2 \qquad (12)$$

that can be easy to estimate and has readily interpretable parameters.

2.3 A money-metric of utility from state education

We consider the effect of the freely provided state education on consumer behaviour along with the effects of demographic and non-demographic characteristics of the h^{th} household, denoted by the vector $z_h = (z_{0h}, z_{1h}, \ldots\ldots, z_{Kh})$. In addition to the number of school-aged children and the type of school attended, vector z_h can include variables found to affect the level and pattern of consumption in studies analysing individual household behaviour with pooled time-series and cross-section data (e.g. Blundell et al. 1993). Such variables can be the number, age, gender, occupation, economic position and employment status of adult members, housing characteristics (location, type, size, central heating, tenure), seasonal dummies, trend and other time varying macro variables.

Let z_0 and z_h denote the vector of characteristics for household 0 and h respectively. The vectors are identical for the two households except for the element s, $z_{s0} \neq z_{sh}$ which denotes the number of children in private education. Then, the value of free of charge state schooling for the h^{th} household can be measured by the money-metric,

$$m_h(\mathrm{z}_{sh}; p, \mathrm{z}_{s0}, U_0) \equiv C(z_{sh}, p, U_0)/C(z_{s0}, p, U_0), \qquad (13)$$

showing the relative cost of a household with children in state education to reach the same utility level (at prices p) as an otherwise identical household with children in private education.

As such (13) is a measure of the compensation a household would accept in order to give up its entitlement to free state schooling for its children, as illustrated in the diagram of Figure 3 in the previous sub-section. Also, as shown in the same diagram, (13) decreases with the cost of supplementing the minimum education provided free of charge by the state with out-of-pocket payments; and will obtain its minimum value (i.e. unity, indicating no value from state schooling) when the expenditure required to achieve a given utility level under a state-plus-supplementation regime (point K in Figure 3) is not higher than that required to achieve the same utility level under an all-private education regime (point K´ in Figure 3).

The validity of (13) as an index of welfare comparison is subject to the usual Independent of Base (IB) restriction (Lewbel, 1989; Blackorby and Donaldson, 1993) required to make such comparison meaningful - at least for utility levels above zero. In general, for a given household characteristic z_{sh}, IB holds when the cost function $C(z_{sh}, p, U_h)$ can be written in the multiplicatively separable form $C_1(p, z_{sh})C_2(p, U_h)$, implying that $\partial \ln C(.)/\partial U_h$ does not depend on the household characteristic in question. Thus, IB here implies that the proportional difference in cost between private and state schooling does not depend on the utility level at which this difference is measured. At first sight this may appear to be at odds with the depiction in Figure 3 that the compensation required for opting out of the state education system decreases with the consumer's budget. This, however, happens due to rising supplementation costs, not because the utility level itself is, ceteris paribus, affected by school type (private or state) attendance. Indeed, given all other characteristics, the fact that both (i) the supplementation costs for households with children in state schools and (ii) the school fees for households with children in private schools increase with real expenditure may render IB here an empirically not invalid hypothesis[4]. We shall return to this point in the empirical analysis below.

[4] As shown by Blundell and Lewbel (1991) not all violations of the IB hypothesis are testable. Therefore, while IB can be rejected if some violations are empirically observed, its validity can never be established on empirical grounds.

3. Empirical analysis

3.1 Model specification

Adopting the Quadratic Logarithmic Almost Ideal Demand System (QUAIDS) functional form proposed by Banks et al. (1997) the price functions in (12), when also allowed to vary with household characteristics z_h, are written as

$$\alpha(p_{gt}, z_h) = \alpha_0(z_h) + \sum_i \alpha_i(z_h) \ln p_{git} + .5 \sum_i \sum_j \gamma_{ij} \ln p_{git} \ln p_{gjt}, \quad (14)$$

$$\beta(p_{gt}, z_h) = \prod_i p_{git}^{\beta_i(z_h)} \quad (15)$$

$$\lambda(p_{gt}, z_h) = \sum_i \lambda_i(z_h) \ln p_{git}, \quad (16)$$

where the h and t subscripts are introduced to denote household and time, respectively.

The subsistence cost $A(c)$ in (12) defined at the top budgeting stage, is also assumed to have the QUAIDS form

$$A(p_t, z_h) = A_0(z_h) + \sum_g A_g(z_h) \ln p_{gt} + .5 \sum_g \sum_m \Gamma_{gm} \ln p_{gt} \ln p_{mt}, \quad (17)$$

as are the indices $B(c) \equiv B(p_t, z_h) = \prod_g p_{gt}^{B_g(z_h)}$ and $\Lambda(c) \equiv \Lambda(p_t, z_h) = \sum_g \Lambda_g(z_h) \ln p_{gt}$.

Based on the functional forms given in (14)-(16) the money-metric of the value from a school-age child in (free of charge) state rather than in (out-of-pocket paid) private education for the h^{th} household, as defined by (13) is given by the equivalence scale

$$\ln m_h(z_h; p, z_0, U_0) = A(p_t, z_h) - A(p_t, z_0) + \left[\frac{B(p_t, z_h)\, U_0}{1 - \Lambda(p_t, z_0) U_0} - \frac{B(p_t, z_0)\, U_0}{1 - \Lambda(p_t, z_0) U_0}\right], \quad (18a)$$

where z_h (the vector of household characteristics, $z_{kh}, k = 1, \ldots, K$) differs only in the s^{th} element $z_{s0} = 0$ and $z_{sh} \neq 0$ for households without and with children in private education, respectively. Furthermore, at given prices and under IB, it simplifies to

$$\ln m_h(z_h; p, z_0, U_0) = A_0(z_{sh}) - A_0(z_{s0}). \quad (18b)$$

The above equivalence scale is the overall money-metric of a child being in state (rather than private) schooling. In the context of our analysis this scale needs to be extended in order to allow for the value of state schooling to be estimated separately for each top stage commodity group; thereby enabling one to capture the education costs pertaining to location in the catchment area of a high performing state school which are 'hidden' in housing expenditure. A simple way to allow for commodity specific equivalence scales in

the empirical specification is to allow $A_0(z_h)$ in (17) to vary with the top stage commodities. Let

$$A_{0g}(z_h^*) = A_0 + \sum_{l=1}^{L} A_{lg} z_h^* \tag{19}$$

where $z_{lh}^*, l = 1, \dots, L$ is a subset of demographic characteristics that affect the allocation of total expenditure at the upper budgeting stage.

Thus equation (17) can be re-written as

$$A_{0g}(p, z_h) = A_0 + \sum_{l=1}^{L} A_{lg} z_{lh}^*, \; + P(z_h, p) \tag{20}$$

where $P(z_h, p) \; = \sum_g A_g(z_h) \ln p_{gt} + .5 \sum_g \sum_m \Gamma_{gm} \ln p_{gt} \ln p_{mt}$. The term $[\ln X - A(c)]$ in (12) can then be expressed as

$$\begin{aligned} \ln[X_h e^{-A_{0g}(p,z_h)}] &= \ln[X_h \textstyle\sum_{g=1}^{G} W_{gh} \, e^{-A_{0g}(p,z_h)}] \\ &= \ln X_h - A_0 - P(z_h, p) + \textstyle\sum_{g=1}^{G} W_{gh} \, e^{-\sum_{l=1}^{L} A_{lg} z_{lh}^*} \end{aligned} \tag{21}$$

where W_{gh} is the (upper stage) share of g^{th} commodity in total expenditure. It should be noted that, since $\sum_{g=1}^{G} W_{gh} = 1$, not all the A_{lg} parameters can be estimated, e.g. set one A_{lg} to be equal for two demographic characteristics, z_{lh}^*; or fixed one of the A_{lg} parameters to some a priori known value.

Using (21), functional forms (14), (15) and (17), the approximation of $P(z_h, p)$ by the Stone index and the assumption $\alpha_i(z_h) = \alpha_i + \sum_k a_{ik} z_{kh}, \; k = 1, \dots, \mathrm{K}$[5] the (lower stage) Marshallian share of commodity i in the budget of household h in period t given by (12) becomes

$$\begin{aligned} \omega_{iht} = \; & \alpha_i + \textstyle\sum_k a_{ik} z_{kh} + \sum_j \gamma_{ij} \ln p_{gjt} \\ & + \beta_i(z_h) \beta(p_{gt}, z_h) \left\{ \ln X_{ht}^* - A_0 + \ln \left[\textstyle\sum_{g=1}^{G} W_{gh} e^{-\sum_{l=1}^{L} A_{lg} z_{lh}^*} \right] \right\} \\ & + \lambda_i(z_h) \left\{ \ln X_{ht}^* - A_0 + \ln [\textstyle\sum_{g=1}^{G} W_{gh} e^{-\sum_{l=1}^{L} A_{lg} z_{lh}^*}] \right\}^2 \end{aligned} \tag{22}$$

where X_h^* is the deflated budget of household h in period t from the first stage budgeting.

Regarding the demographic characteristics in the empirical model we use two variables: z_{1h}^* and z_{2h}^*, denoting the total number of school-age children in the household and the

[5] It is a standard practice in empirical demand analysis based on individual household data (e.g. Blundell et al. 1993) to model the household-specific intercepts of the budget share equations as linear functions of household characteristics. Furthermore, the parameter A_0, corresponding to the subsistence (log) cost of the reference household, defined by $z_{lh}^* = 0$ all l, is fixed at a level equal to the mean base year log expenditure of the poorest 1% of households in the sample.

number of children in private education, respectively; and two commodity shares in total (upper stage) household expenditure, W_{1h} and $W_{2h,}$ denoting housing and other commodities, respectively. Thus for the estimation of (22) we set

$$\ln\left\{\sum_{g=1}^{G} W_{gh} e^{-\sum_{l=1}^{2} A_{lg} z_{lh}^{*}}\right\} = \ln\left\{W_{1h} e^{-(A_{11} z_{1h}^{*} + A_{21} z_{2h}^{*})} + W_{2h} e^{-(A_{12} z_{1h}^{*} + A_{22} z_{2h}^{*})}\right\} \quad (23)$$

where the restriction $A_{11} = A_{12}$ is imposed for identification (as explained earlier). Thus, the cost of children is assumed to be proportional to the share of housing and other goods in total expenditure; whereas, the cost of children in private education is allowed to differ with the share of housing and other goods.[6]

It then follows from (18b) that the relative cost of: (a) households with z_{1h}^{*} children to reach the same utility as a household with z_{10}^{*} children is

$$\ln m_h\left(z_{1h}^{*}; p, z_{10}^{*}, U_0\right) = \ln\left[\frac{W_{1h} e^{-A_{11} z_{1h}^{*}} + W_{2h} e^{-A_{12} z_{1h}^{*}}}{W_{1h} e^{-A_{11} z_{10}^{*}} + W_{2h} e^{-A_{12} z_{10}^{*}}}\right]; \quad (24)$$

and (b) households with z_{1h}^{*} children of whom z_{2h}^{*} are in private education to reach the same utility as a household with z_{10}^{*} children of whom z_{20}^{*} are in private education

$$\ln m_h\left(z_{h}^{*}; p, z_{o}^{*}, U_0\right) = ln\left[\frac{W_{1h} e^{-(A_{11} z_{1h}^{*} + A_{21} z_{2h}^{*})} + W_{2h} e^{-(A_{12} z_{1h}^{*} + A_{22} z_{2h}^{*})}}{W_{1h} e^{-(A_{11} z_{10}^{*} + A_{21} z_{20}^{*})} + W_{2h} e^{-(A_{12} z_{10}^{*} + A_{22} z_{20}^{*})}}\right]. \quad (25)$$

Estimation of (22) is conducted using nonlinear SUR under:

(i) the integrability restrictions $\sum_i a_i = 1$, $\sum_k a_{ik} = \sum_i \beta_i(z_h) = \sum_i \lambda_i(z_h) = 0$, $\sum_i \gamma_{ij} = 0$ all j for adding-up; $\sum_j \gamma_{ij} = 0$ all i for homogeneity; $\gamma_{ij} = \gamma_{ji}$ for symmetry; and

(ii) the IB restrictions $\beta_i(z_h) = \beta_i$ and $\lambda_i(z_h) = \lambda_i$.

3.2 Empirical results

Consumer behaviour at the lower stage budgeting is modelled on two categories of nondurable goods: "Food and Catering" and "Other Goods". The group "Other Goods" includes the subcategories of fuel, clothing, transport and communication, household goods and services, personal and leisure goods and services. The data used are drawn

[6] Note that when the commodity specific equivalence scales are set to be identical, $A_{lg}(z_{lh}^{*},) = A_l(z_{lh}^{*})$, then $\sum_{g=1}^{G} W_{gh} e^{-\sum_{l=1}^{L} A_{lg} z_{lh}^{*}} = -\sum_{l=1}^{L} A_l z_{lh}^{*}$, and (22) obtains the standard QUAIDS form

$\alpha_i(z_h) + \sum_{j=1}^{n} \gamma_{ij} \ln p_{gjt} + \beta_i(z_h)\beta(p_{gt}, z_h)\{\ln X_{ht}^{*} - A_0 - \sum_{l=1}^{L} A_l z_{lh}^{*}\} + \lambda_i(z_h)\{\ln X_{ht}^{*} - A_0 - \sum_{l=1}^{L} A_l z_{lh}^{*}\}^2$,

where $A_l(z_{lh}^{*})$ is the typical IB equivalence scale for the l^{th} demographic characteristic.

from the UK 2001-2012 Living Costs and Food Survey (LCF)[7]. The sample drawn consists of two-adult (non-retired) households without children or with children up to 16 years old attending either private or state pre-primary, primary or secondary education.[8] This result in 22331 observations, 61.2% of which correspond to households without and 38.8% to households with children in the specified age group; about 3.5% of the latter group has children only in private schools and 2% has children in both private and state schools. A more detailed description of the data used in the empirical analysis is given in the Appendix.

As said earlier in the paper, for households supplementing the minimum state education with additional quantities purchased through locating themselves in the catchment area of high performing state schools, an element of the housing expenditure recorded in the data represents expenditure on education. Furthermore, this housing-and-education expenditure in the LCF includes mainly mortgage payments and other current accommodation costs and does not reflect the correct level of this joint commodity consumed in a particular time period, and its associated 'user cost'. To overcome this problem we assume that the latter cost can be measured by the rent paid by non-owner-occupiers. Then, using a Heckman type approach we extrapolate the imputed rent for owner-occupiers from the empirical results obtained from a model whereby the decision to rent and the rent paid are determined simultaneously by characteristics of the house and the household.[9]

The empirical results are obtained from SUR estimation of the model defined by specification (22). Table 1 reports selected child cost parameter estimates and diagnostic statistics that are of interest to the issues raised in this article, together with the corresponding t-statistics or p-values. It also reports the estimated linear (β_i) and

[7] In 2008 the Expenditure and Food Survey (EFS) became a module of the Integrated Household Survey (IHS) and was renamed to Living Costs and Food Survey (LCF). The EFS was the result of the amalgamation of the Family Expenditure Survey (FES) and the National Food Survey (NFS) in 2001.

[8] This was motivated by the need to limit heterogeneity among households to demographic characteristics of interest, i.e. the number of children of schooling age. Extending the sample to include other household categories, for example households with more than two adults, households with household reference person over 65 or households with children also in higher education level, would introduce further heterogeneity and require the inclusion of additional parameters in the demand system. Thus, it is important to point out that the empirical results in this study may not hold for types of households substantially different from those in the selection considered.

[9] The data used in the empirical estimation of a Heckman model include all households with and without children whose household reference person (hrp) is under retirement age. Variables on housing characteristics (total rooms, heating, region e.tc), household characteristics (number of adults, number of children, age of the household reference person, e.tc) and also expenditure on council, water and sewerage tax are included in both structural and selection equation. Income sources of the hrp were also included into the selection equation for identification purposes. The estimation results, obtained by maximum likelihood, are shown in the Appendix.

quadratic (λ_i) log expenditure parameters, price effects (γ_{ij}) as well as the budget and price elasticities.[10] The remaining parameter estimates, which show the effect of household characteristics in the budget share equations, are reported in the Appendix.

Table 1: Selected parameter estimates and system statistics

	Coefficient	t-ratio
Equivalence scales		
Child (A_{11}=A_{12})	0.177	14.1
Commodity specific		
Child in private school: housing (A_{21})	-0.250	-2.26
Child in private school: other goods (A_{22})	0.286	2.57
Parameter estimates		
Log expenditure (β_i)		
Food and Catering	-0.128	-21.48
Other nondurable	0.128	21.48
Log expenditure square (λ_i)		
Food and Catering	0.014	4.66
Other nondurable	-0.014	-4.66
Log price		
γ_{11} and γ_{22}	0.092	4.39
γ_{12} and γ_{21}	-0.092	-4.39
Elasticities	**Food**	**Other nondurable**
Own price elasticity	-0.55	-0.83
Cross price elasticity	-0.45	-0.17
Budget elasticity	0.61	1.14
Tests		
Objective	0.9984	
Objective∗Number of Observations	22287	
Symmetry/Homogeneity test (*chi-square*)	p-value: 0.317	
Separability test	p-value: <0.0001	
Non-IB test: private schooling[1]	LR = 8.34 (p-value: 0.079)	
child and private schooling[2]	LR = 7.89 (p-value: 0.019)	

[1] The model is estimated by setting $\beta_{ih} = \beta_{i0} + \beta_{i1} z_{2h}^*$ and $\lambda_{ih} = \lambda_{i0} + \lambda_{i1} z_{2h}^*$ and testing $\beta_{i1} = \lambda_{i1} = 0$ where z_{2h}^* denotes the number of children in private education in the household,.

[2] The model is estimated by setting $\beta_{ih} = \beta_{i0} + \beta_{i1} z_{1h}^* + \beta_{i2} z_{2h}^*$ and $\lambda_{ih} = \lambda_{i0} + \lambda_{i1} z_{1h}^* + \lambda_{i2} z_{2h}^*$ and testing $\beta_{i1} = \beta_{i2} = \lambda_{i1} = \lambda_{i2} = 0$ where z_{1h}^* and z_{2h}^* denote the number of children and the number of children in private education in the household, respectively.

The estimates show that in order to be at the same level of utility compared to an identical household without children, a household with a child needs to increase total expenditure by 17.7%. Furthermore, at the top budgeting stage households with children in private schools allocate less expenditure to housing than to other goods, as indicated by the parameters $A_{21} < 0$ and $A_{22} > 0$. Using the mean shares of housing

[10] As in Banks at al. (1997), the elasticities are computed for the average household using the estimated parameters and the fitted values of the budget shares.

($\overline{W}_1 = 0.33$) and other goods ($\overline{W}_2 = 0.67$) and the parameter estimates A_{21} and A_{21} in equation (25) the cost of a child for a couple (relative to a couple without children, $z_{10}^* = 0$) is given by

$$\ln m_h\,(z_{1h}^*; p, z_{10}^*, U_0) = \ln[\overline{W}_1 e^{-A_{11}} + \overline{W}_2 e^{-A_{12}}]$$

$$= \ln[.33e^{.177} + .77e^{.177}] = \ln[e^{.177}] = .177, \qquad (26a)$$

and for a couple with a child in private schooling by

$$\ln m_h\,(z_{2h}^*; p, z_{20}^*, U_0) = \ln\left[\overline{W}_1 e^{-(A_{11}+A_{21})} + \overline{W}_2 e^{-(A_{12}+A_{22})}\right]$$

$$= \ln\left[\overline{W}_1 e^{-(.177-.250)} + \overline{W}_2 e^{-(.177+.286)}\right] = \ln[.35 - .42] = .25. \qquad (26b)$$

Thus, state (relative to private) schooling is associated with a reduction in the cost of achieving a given utility level by 7.3 percentage points. However, this is not reflected in an equi-proportional reduction of spending on all commodities. In fact, it is made up from an increase of the share of housing spending in total expenditure by a factor $e^{-(.177-.250)} = 1.08$ (i.e. an increase by 8%); and a decrease of the share of other goods by a factor $e^{-(.177+.286)} = 0.63$ (i.e. a decrease by 37%). This result reflects the fact that households supplement the state education of their children via purchasing more expensive dwellings in the catchment area of high quality state schools. We shall return to this point below.

Commending on other results reported in Table 1, the linear and quadratic log expenditure effects are both significant at 0.01 levels. "Food and Catering" appears to be a necessity good (negative β_i and positive λ_i) and "Other" nondurable goods to be luxury (positive β_i and negative λ_i). As regards price effects, there are only two budget share equations in our empirical analysis so that the adding up ($\gamma_{11} + \gamma_{21} = \gamma_{12} + \gamma_{22} = 0$) together with the homogeneity ($\gamma_{11} + \gamma_{12} = \gamma_{21} + \gamma_{22} = 0$) and symmetry ($\gamma_{12} = \gamma_{21}$) restrictions imply that $\gamma_{12} = \gamma_{21}$ jointly tests for homogeneity and symmetry. This restriction is not rejected at 0.05 level. Separability, however, (tested as the joint significance of the top stage quantities in the lower stage budget shares) is rejected, indicating that the prices of commodities determined at the top budgeting stage affect the lower stage allocation of non-durable expenditure.

In the context of our analysis the hypothesis that can have important implications for the interpretation of the results is IB. This hypothesis is empirically tested as the independence of the (utility) parameters, β's and λ's of household characteristics

entering the calculation in money metrics of welfare. In this paper the money metric of particular concern is the value of state education as perceived by households. Thus IB requires β's and λ's not to depend on whether a child attends state or private school. As shown in Table 1 this hypothesis is not rejected at the 0.05 significance level.[11]

The estimated cost of education reported in Table 2, suggests a difference of 9749 EUR (annually, in 2014 prices) between the mean expenditure of households with a child in private (18910 EUR) and state education (9161 EUR). However, for households not supplementing state education through acquiring accommodation in the catchment area of a high quality state school the mean child cost in state schooling is reduced by about 1379 EUR (becomes 7782 EUR).[12] This amount is around 7.5% of the mean housing expenditure, as also suggested by the literature using the hedonic valuation of school quality (Black and Machin, 2011).

Table 2: Child cost in private and public education in the UK

Child cost	Monetary values (euro 2014)
Mean child cost in private education	18910
Mean child cost in state education with supplementation	9161
Mean child cost in state education without supplementation	7782
Mean value of free state education (mean child exp. private - mean child exp. state)	9749
Government expenditure per pupil[1]	8027
Government expenditure per pupil plus supplementation	9406

Notes: [1]Eurostat and authors' calculations

Commenting further on the results reported in Table 2 one can say:

- Comparing the government (production) cost of education per school-age child (8027 EUR) with the corresponding amount which, households are willing to pay (on average 9749 EUR) one can characterise the state provision of education system in the UK as 'efficient', in the sense that the benefit of state education perceived by households exceeds its production cost.

- Strictly speaking the government (production) cost of education in the UK National Accounts understates the true cost of education incurred by households by 1379

[11] In the case where the β'_s *and* λ'_s, however, are also allowed to depend on the number of children IB is rejected at the same significance level. This result implies that welfare comparisons between households can only be valid at subsistence level (zero utility).

[12] This number is equal to the 8% (the increase of the share of housing spending in total expenditure) of the mean housing expenditure.

EUR per child, i.e. the additional (to taxes and rates) housing cost for locating themselves in the catchment area of a high quality state school.

- The diagrammatic exposition in Section 2 and the empirical results in this section of the paper imply that the supplementation of state schooling with out-of-pocket payments enables households to increase consumption of education above the minimum provided free of charge by the state, if they are willing to do so. This improves allocative efficiency but does not help decrease inequality (as suggested by Besley and Coate, 1991) because it encourages a smaller number of households to opt out of free state schooling.

4. Conclusion

The free of charge provision of a minimum level of education by the state is a world-wide phenomenon, based on both efficiency and equity criteria. There is an extensive literature examining a wide range of issues concerning this provision; however, the value of free of charge state education to consumers has not received enough attention in the literature. Empirical estimates of willingness to pay obtained from contingent valuation studies are specific to the design and conduct of an ad hoc survey. Whereas, hedonic analysis can yield a money-metric of school quality but this metric cannot be integrated in a model of consumer behaviour to measure utility from freely provided state education.

This paper proposes a novel method to estimate the value of state education which is perceived by those consuming it and defined as a money-metric of willingness to opt out of the state education system. The proposed method, first illustrated diagrammatically and then formulated as complete demand analysis model, accounts for the fact that households supplement the free of charge state education with out-of-pocket payments through locating themselves in the catchment area of high quality state schools. The model used for empirical analysis accords with the most general (rank-3) empirical representation of consumer preferences, while adhering to the fundamentals of consumer theory; and can be estimated from household survey data routinely available in many countries. A novel feature of this model is the capacity to allow child costs to vary between the components of total (top budgeting stage) household expenditure, i.e. between non-durable and various types of durable goods (e.g. housing).

The results obtained from the application of the model to UK household data drawn from the UK 2001-2012 Expenditure and Food Survey (a total of 22331 observations) show that state (relative to private) schooling is associated with a reduction in the cost of achieving a given utility level by 7.3%. However, this is not reflected in an equi-proportional reduction of spending on all commodities: it is made up from an increase of the share of housing spending and a (relatively larger) decrease of the share of other goods, reflecting the supplementation of state education through purchasing more expensive dwellings in the catchment area of high quality state schools. Our empirical findings suggest that this supplementation costs 1379 EUR per school-age child (7.3% of the mean housing expenditure).

Supplementation of state schooling with out-of-pocket payments improves allocative efficiency but does not help decrease inequality, insofar as it discourages better off households to opt out of free of charge state schooling. On average, we find that households pay 9749 EUR per school-age child for state education. This amount is above the government (production) cost of education (8027 EUR per school-age child) and can be interpreted as a measure of 'efficiency' of state education in the UK. At the same time, however, the same result also implies that the government expenditure on education recorded in the UK National Accounts understates the true cost incurred by households by 1379 EUR per child.

The analysis in the paper can also be used to examine equity aspects of education vis-à-vis the ability of households to use out-of-pocket payments in order to acquire access to better quality education for their children. These and other theoretical and empirical results in the paper (i.e. opting for exclusively private schooling when supplementation cannot meet the education requirements of the household) can guide policies towards a more informed and constructive analysis of the role which can be played by the state and private education sectors; notwithstanding, of course, positive externality and social policy aspects of education, at large.

References

Aaberge R., M. Bhuller, M. Langørgen, and M. Mogstad (2010), "The distributional impact of public services when needs differ", *Journal of Public Economics,* 94, 549-562.

Banks J., R. Blundel and A. Lewbel (1997), "Quadratic Engel Curves and Consumer Demand", *Review of Economics and Statistics*, 4, 527-539.

Bearse P., G. Glomm and D. M. Patterson (2005), "Endogenous Public Expenditures on Education*", Journal of Public Economic Theory*, 7, 561–577.

Besley T. and S. Coate (1991), "Public Provision of Private Goods and Redistribution", *American Economic Review*, 81, 979-984.

Black S. (1999), "Do Better Schools Matter? Parental Valuation of Elementary Education", *The Quarterly Journal of Economics*, 114, 2, 577-599.

Black S. and S. Machin (2011), "Housing Valuations of School Performance" The Handbook of the Economics of Education, 3, 485-519.

Blackorby C. and A. Shorrocks (1996), eds, Collected Works of W.M. Gorman: Separability and aggregation, Clarendon Press, Oxford.

Blackorby C. and D. Donaldson (1993), "Adult-equivalence scales and economic implementation of interpersonal comparisons of well-being", *Journal of Public Economics*, 50, 143–146.

Blomquist S. and V. Christiansen (1995), "Public Provision of Private Goods as a Redistributive Device in an Optimum Income Tax Model", *Scandinavian Journal of Economics* , 97, 547-567.

Blomquist S. and V. Christiansen (1999), "The Political Economy of Publicly Provided Private Goods", *Journal of Public Economics*, 73, 31-54.

Blundell R., P. Pashardes and G. Weber (1993), "What do we learn about consumer demand patterns from micro-data", *American Economic Review*, 83, 570-597.

Blundell R. and A. Lewbel (1991), "The Information Content of Equivalence Scales", *Journal of Econometrics*, 50, 46-68.

Brookshire D. S. and D. Coursey (1987), "Measuring the Value of a Public Good: An Empirical Comparison of Elicitation Procedures", American Economic Review, 77, 554-566.

Clapp J., A. Nanda and S. Ross (2008), "Which School Attributes Matter? The Influence of School District Performance and Demographic Composition of Property Values", *Journal of Urban Economics,* 63, 451–466.

Clinch J. and A. Murphy (2001), "Modelling winners and losers in contingent valuation of public goods: appropriate welfare measures and econometric analysis". *The Economic Journal*, 111, 420-442.

Cohen-Zada D. and M. Justman (2003), "The political economy of school choice: linking theory and evidence", *Journal of Urban Economics* 54, 277–308.

De La Croix D. and M. Doepke (2009), "To Segregate or to Integrate: Education Politics and Democracy", *Review of Economic Studies*, 76, 597–628.

Deaton A. and J. Muellbauer (1980), Economics and Consumer Behavior, Cambridge University Press, New York.

Epple D., R. Romano and H. Sieg (2012), "The intergenerational conflict over the provision of public education", *Journal of Public Economics*, 96, 255-268.

Epple D. and R. Romano (1996), "Public provision of private goods", *Journal of Political Economy*, 104, 57-84.

Epple D. and R. Romano (1998), "Competition between Private and Public Schools, Vouchers, and Peer-Group Effects", *American Economic Review*, 88, 33-62.

Fack G. and J. Grenet (2010), Do Better Schools Raise Housing Prices? Evidence from Paris School Zoning, *Journal of Public Economics*, 94, 59-77.

Gahvari F. and E. Mattos (2007), "Conditional Cash Transfers, Public Provision of Private Goods, and Income Redistribution", *The American Economic Review*, 97, 491-502.

Gorman T. (1981), Some Engel curves, in Essays in the Theory and Measurement of Consumer Behaviour in Honor of Richard Stone, ed. A. Deaton, Cambridge University Press.

Hanemann W. M. (1994), "Valuing the Environment Through Contingent Valuation", *Journal of Economic Perspectives*, 8, 19-43.

Ladd H. (2002), "School Vouchers: A critical View", *The Journal of Economic Perspectives*, 16, 3-24.

Levy G. (2005), "The Politics of Public Provision of Education", *The Quarterly Journal of Economics*, 120, 1507-1534.

Lewbel A. (1989), "Household equivalence scales and welfare comparisons", *Journal of Public Economics*, 39, 377–391.

Lewbel A. (1991), "Cost of Characteristics Indices and Household Equivalence Scales", *European Economic Review*, 35, 1277-1293.

Nechyba T. (1999), "School Finance Induced Migration and Stratification Patterns: The Impact of Private School Vouchers", *Journal of Public Economic Theory,* 1, 5-50.

Nechyba T. (2000), "Mobility, Targeting, and Private Schools Vouchers", *The American Economic Review*, 90, 130-146.

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

Appendix

Table A1: Descriptive Statistics for all variables

Variable	Mean	Std. Dev.	Min	Max
Shares:				
Food	0.269	0.108	0	0.928
Other goods and services	0.731	0.108	0.072	1
Log household expenditure (Upper Stage)	6.194	0.444	4.630	7.316
Log household expenditure (Lower Stage)	5.602	0.555	2.244	7.191
Survey years:				
2001	0.104	0.305	0	1
2002	0.094	0.292	0	1
2003	0.100	0.300	0	1
2004	0.098	0.297	0	1
2005	0.094	0.292	0	1
2006	0.093	0.290	0	1
2007	0.087	0.281	0	1
2008	0.078	0.269	0	1
2009	0.062	0.242	0	1
2010	0.055	0.227	0	1
2011	0.059	0.236	0	1
2012	0.076	0.265	0	1
Quarters:				
quarter1	0.246	0.431	0	1
quarter2	0.248	0.432	0	1
quarter3	0.252	0.434	0	1
quarter4	0.253	0.435	0	1
Household characteristics:				
Number of children	0.718	1.017	0	4
Number of children only in state schools	1.842	0.752	1	4
Number of children only in private schools	1.389	0.564	1	4
Number of children both in state and private schools	2.506	0.680	2	4
Gas heating	0.774	0.418	0	1
Oil heating	0.111	0.314	0	1
Elecricity heating	0.046	0.211	0	1
Detached house	0.310	0.462	0	1
Semi-detached house	0.334	0.472	0	1
Terraced house	0.249	0.432	0	1
Total rooms>5	0.592	0.491	0	1
Number of vehicles	1.492	0.733	0	8
Regions:				
Mesyside and North West	0.106	0.307	0	1
Yorkshire and Humberside	0.086	0.280	0	1
North East	0.039	0.195	0	1
East Midlands	0.078	0.268	0	1
West Midlands	0.083	0.276	0	1
East Anglia	0.097	0.296	0	1
London	0.072	0.258	0	1
South East	0.142	0.349	0	1
South West	0.094	0.291	0	1
Wales	0.048	0.215	0	1
Scotland	0.087	0.282	0	1
Northern Ireland	0.067	0.250	0	1
Household reference person characteristics:				
Married	0.846	0.361	0	1
White	0.942	0.233	0	1
Male	0.761	0.426	0	1
Age	45.966	11.584	18	65
Unemployed	0.018	0.132	0	1
Owner of the house	0.234	0.424	0	1
Income source: wages	0.741	0.438	0	1
Income source:Self employed	0.095	0.293	0	1

Table A2 : QUAIDS parameter estimates corresponding to household characteristics

Characteristics	Food and Catering		Other nondurable goods	
	Coef.	t-ratio	Coef.	t-ratio
Number of vehicles	-0.016	-15.200	0.016	15.200
House with more than 5 rooms	0.003	1.900	-0.003	-1.900
Children in household	0.001	0.52	-0.001	-0.52
Age of hrp	0.291	4.050	-0.291	-4.050
Age of hrp squared	-0.036	-3.660	0.036	3.660
Male (hrp)	0.001	0.340	-0.001	-0.340
Married (hrp)	-0.003	-1.390	0.003	1.390
White (hrp)	0.017	5.920	-0.017	-5.920
Unemployed (hrp)	0.002	0.310	-0.002	-0.310
Income source: wages	-0.010	-4.850	0.010	4.850
Income source: self employed	0.003	1.060	-0.003	-1.060
Gas heating	0.004	1.940	-0.004	-1.940
Oil heating	0.001	0.330	-0.001	-0.330
House:owned outright	-0.001	-0.720	0.001	0.720
Detached house	-0.009	-3.280	0.009	3.280
Semi-detached house	-0.011	-4.480	0.011	4.480
Terraced house	-0.013	-5.430	0.013	5.430
Mesyside and North West	0.003	0.730	-0.003	-0.730
Yorkshire and Humberside	0.002	0.600	-0.002	-0.600
East Midlands	0.005	1.350	-0.005	-1.350
West Midlands	0.007	1.880	-0.007	-1.880
East Anglia	0.016	4.080	-0.016	-4.080
London	0.054	13.020	-0.054	-13.020
South East	0.018	4.880	-0.018	-4.880
South Wset	0.013	3.250	-0.013	-3.250
Wales	0.006	1.460	-0.006	-1.460
Scotland	0.013	3.290	-0.013	-3.290
Northern Ireland	0.021	4.570	-0.021	-4.570
Second Quarter	-0.005	-2.880	0.005	2.880
Third Quarter	-0.004	-2.000	0.004	2.000
Fourth Quarter	0.001	0.480	-0.001	-0.480

Table A3: Estimation results of the sample selection model[a]: Composite commodity

	Rent Expenditure		Selection Equationd	
	Coef[b].	s.e	Coef[b].	s.e
Constant	3.605***	(0.081)	-3.213***	(0.120)
Log total household Expenditure	0.200***	(0.010)	0.509***	(0.015)
Region (South East)[c]:				
Yorkshire and Humberside	-0.270***	(0.017)	-0.133***	(0.033)
North West and Mesyside	-0.221***	(0.016)	-0.126***	(0.031)
North East	-0.302***	(0.024)	-0.307***	(0.044)
East Midlands	-0.285***	(0.018)	-0.032	(0.035)
West Midlands	-0.167***	(0.018)	-0.173***	(0.034)
Eastern	-0.079***	(0.017)	-0.035	(0.032)
London	0.258***	(0.015)	-0.098***	(0.031)
South West	-0.136***	(0.016)	0.050	(0.032)
Wales	-0.240***	(0.022)	-0.151***	(0.042)
Scotland	-0.225***	(0.027)	-0.513***	(0.050)
Northern Ireland	-0.033	(0.030)	-0.553***	(0.058)
Other Characteristics				
Total rooms (more than five)[c]:				
House with 1 rooms	-0.237***	(0.050)	1.096***	(0.142)
House with 2 rooms	-0.212***	(0.026)	0.564***	(0.061)
House with 3 rooms	-0.092***	(0.017)	0.334***	(0.034)
House with 4 rooms	-0.043***	(0.013)	0.264***	(0.024)
House with 5 rooms	-0.039***	(0.011)	0.138***	(0.020)
Number of economically active persons	-0.041***	(0.006)	-0.020	(0.014)
Number of adults	0.082***	(0.007)	0.017	(0.014)
Number of children	0.017***	(0.004)	-0.116***	(0.008)
Council tax	0.015***	(0.001)	-0.008***	(0.002)
Council water tax	0.007	(0.009)	-0.011	(0.013)
Number of vehicles	-0.016**	(0.007)	-0.293***	(0.012)
Age of hrp	_	_	-0.032***	(0.001)
Heating type (other)c:				
Electricity	0.065***	(0.016)	-0.084**	(0.033)
Gas	0.133***	(0.013)	-0.366***	(0.025)
Oil	0.025	(0.021)	0.120***	(0.039)
House Type (other)c:				
Detached	0.005	(0.019)	-0.311***	(0.033)
Semi-detached	0.004	(0.014)	-0.316***	(0.026)
Terraced	-0.017	(0.012)	-0.136***	(0.023)
Durables in the house:				
Freezer	-0.035**	(0.016)	0.354***	(0.035)
Microwave	-0.002	(0.012)	0.152***	(0.025)
Dishwater	-0.107***	(0.011)	0.331***	(0.020)
Source of Income (wages)c:				
Investment	0.115**	(0.050)	-0.003	(0.084)
Social security benefits	0.155***	(0.012)	0.367***	(0.025)
Other			0.876***	(0.060)
Self-employment			0.105***	(0.031)
Annuities			-0.057	(0.047)
Survey Year (2001)c:				
2002	0.011	(0.021)	-0.010	(0.038)
2003	-0.022	(0.020)	0.153***	(0.037)
2004	0.009	(0.020)	0.214***	(0.037)
2005	0.069***	(0.020)	0.228***	(0.037)
2006	0.073***	(0.020)	0.282***	(0.037)
2007	0.106***	(0.020)	0.315***	(0.038)
2008	0.127***	(0.021)	0.334***	(0.039)
2009	0.126***	(0.021)	0.458***	(0.038)
2010	0.135***	(0.021)	0.521***	(0.040)
2011	0.153***	(0.021)	0.534***	(0.039)
2012	0.154***	(0.021)	0.603***	(0.039)

Notes: [a] The number of observations is 7329 for the rent expenditure regression (number of households that pay rent) and 70403 for the selection equation. The estimated standard error of the rent expenditure equation is 0.347. The estimated correlation between the errors of the rent expenditure and selection equations is -0.405 (s.e.=0.029) and the LR test for the independence of the two equations ($\rho=0$) gives a p-value equal to 0.000 (chi-squared statistic=157.95); [b]The symbols *, ** and *** denote statistical significance at 10%, 5% and 1%; [c] The variable in the brackets is excluded from the regression and is used as the benchmark for comparison.