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Consumer welfare from publicly supplemented private goods: age and income effects on demand for health care

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Abstract In spite of major advances in the theoretical, positive and normative, literature analysing the welfare implications of public provision of private goods, empirical investigation is often limited to contingent valuation studies, for example, of health care programmes. In this article we argue that when a market for a (subsidised or free of charge) publicly provided good exists, a consumer demand approach can be used to construct a money metric of welfare corresponding to the consumption of public provision. We illustrate this approach in investigating age and income effects on household demand for health care in Cyprus, where free public provision is not universal and those entitled to it often resort to private supplementation. Our findings suggest that the money metric of welfare, which consumers attach to free access to publicly provided health care, varies with age and to a lesser extent with household income.

Keywords Public provision · Demand analysis · Consumer welfare

JEL Classification D1

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1 Introduction

A considerable proportion of public funds is channeled into the provision of private goods, such as health care and education for which, normally there also exist private markets. The design of the public provision scheme often allows the eligible individuals to supplement their consumption with purchases from the private sector. The purpose of this article is to explore the case where consumer theory can be used in order to construct a money metric of the welfare individuals derive from the consumption of publicly provided private goods, that is estimable by applying demand analysis to accessible data. We use this approach to investigate the extent to which consumer welfare from access to free public health care varies with age and income.

In the literature there are two main strands analysing the role of public provision of private goods: positive and normative theories. In positive (voting) models, public provision of private goods is a political phenomenon induced by voting (Epple and Romano 1996; Gouveia 1996). In normative (welfare) models public provision is introduced to mitigate market imperfections (such as excludability, imperfect information, externalities, etc.) and, under certain conditions, is shown to work as a means for income redistribution and efficiency enhancement. Blomquist and Christiansen (1999) combine the positive and normative approaches and establish that efficient public provision of private goods can arise from politically rational voting, under asymmetric information.

Using the example of medical care, Blackorby and Donaldson (1988) show that under incomplete information and ration or subsidisation/taxation, efficiency and redistribution can be achieved when self-selection constraints are enforced. Besley and Coate (1991) rely also on self-selection to demonstrate that universal public provision of private goods can redistribute income from 'rich' to 'poor', when public provision is financed by a head tax and its quality matters to the individuals. The redistributive effects of public provision in the presence of a private market, where consumers can pay for extra quality, are also analysed in Ireland (1990). The empirical findings in this article conform to the theoretical arguments above, in the sense that those who benefit from free access to health care appear to be mostly low income households.

It is worth emphasising that allowing supplementation of public provision with privately purchased quantities of the same good, as we do in this article, is neither mandatory nor optimal. Particularly, in the case of health care, the coexistence of public and private provision in relation to redistribution when the quality of health care is represented by waiting time, is analysed by Hoel and Saether (2003) and Marchand and Schroyen (2005). Iversen (1997) investigates the effect of private sector on the waiting time for receiving a treatment in the public sector.

The focus in our analysis is not on how an (optimal) public provision scheme is decided but rather on what such a scheme, once in place, means to potential beneficiaries, the consumers of the publicly provided good. More specifically, we are interested in the welfare implications of public provision as perceived by the individual household and measured empirically from data readily available in household expenditure surveys. A related empirical literature deals with the measurement and monetary valuation of in-kind benefits such as health care, education, child care, etc, mainly for studying income distribution and well-being (see for example Aaberge and

Langørgen 2006; Smeeding et al. 1993; Wolfe and Moffitt 1991). These studies employ methods that are data demanding since they combine information from a number of different sources to construct household/individual-specific values (indices) for the benefit from publicly provided private goods, which depend on various demographic characteristics, household composition, eligibility for in-kind benefits, etc. Moreover, these values of in-kind benefit are not always comparable across countries (Smeeding et al. 1993). Alternatively, the economic evaluation of publicly provided goods such as health care, is tackled empirically through contingent valuation studies for eliciting consumers' willingness to pay, for example, for health care programmes (e.g. Diener et al. 1998 and Olsen and Smith 2001 provide reviews of the literature). However, the usefulness of willingness-to-pay studies for public policy purposes is questioned (Olsen and Smith 2001; Steward et al. 2002).

The contribution of this article lies in the use of an integrable demand system to evaluate utility from a publicly provided private good, namely health care, and investigate age and income effects. We consider the latter effects to be important in view of the escalating public expenditure on health care due to population ageing and in the light of arguments for curbing this expenditure by targeting free public provision to those in need. The role of age and income in consumer demand for health care has long been recognised in the literature. Grossman (1972) provides a theoretical justification for the use of age and income in analysing demand for health. Besley et al. (1999) study the probability that an individual owns private health insurance and find that higher household income is associated with greater probability of purchasing private health insurance. They also find that middle-aged individuals have higher probability of owning private insurance than individuals in their 30s and over 65, a result reflecting heavily on our own empirical findings. Other studies demonstrating the importance of income and/or age on health care include Propper (2000) and Atella et al. (2004). These studies examine consumers' behaviour with regard to only one good, health care, hence no welfare implications can be readily derived.

In our theoretical analysis the benefit of the publicly provided private good is introduced in the consumer's optimisation problem as a parameter scaling the market price of the good in question, along the lines first shown by Barten (1964). The scaling, which can vary with consumer characteristics and other variables reflecting, for example, the perceived quality of the publicly provided good, gives rise to a measure of the reduction in total expenditure attributed to public provision. This money metric of utility from the public provision can then be empirically estimated using data from a household expenditure survey and information about eligibility to free access to this provision. We illustrate our approach in the case of health care in Cyprus, where the public provision scheme is not universal and permits supplementation.

Section 2 considers how free of charge public provision of private goods can be incorporated in a consumer demand system through price scaling. In Sect. 3 an empirical model is specified. Section 4 discusses the estimation results obtained from the empirical model. Section 5 analyses the welfare implications of the empirical findings for households at different incomes and ages of their head and compares them with those from a simpler model. Section 6 concludes this article.

2 Consumer demand

Below we present a consumer demand model where the consumer, via the utility maximisation problem, chooses the level of private commodity i simultaneously with the level of the corresponding publicly provided good, thereby, supplementing the consumption of a publicly provided private good with out-of-pocket purchases. The demand system derived provides a description of consumer behaviour in the presence of publicly (free of charge) provided private goods.

We consider utility to be derived from the joint consumption of publicly provided and privately purchased goods, as defined by the utility function

$$U(q_{1h} + Q_{1h}, \ldots, q_{nh} + Q_{nh}) \quad (i = 1, 2, \ldots, n) \tag{1}$$

where q_{ih} is the quantity of the ith privately purchased good and Q_{ih} is the quantity of the corresponding publicly provided good consumed by household h. We assume that the consumer perceives q_{ih} and Q_{ih} as the same good, differing only in terms of quality and transforming from one to the other via a linear equation

$$Q_{ih} = \theta_i(z_h) q_{ih} \equiv \theta_{ih} q_{ih},$$

where z_h is a vector of household characteristics and $\theta_{ih} \in [0, \infty)$ is a scaling function indicating how household characteristics affect the perceived quality of the publicly provided private good.

The assumption that the private and public goods differ only in quality, so that the one can be expressed as a (household-specific) linear transformation of the other, allows demand for the unobserved publicly provided good to be determined in the consumer optimisation problem together with the demand for the observed privately purchased good. This facilitates the empirical analysis without being particularly restrictive. It essentially means that the consumer considers $Q_{ih} + q_{ih}$ as a 'package' and together with how much to consume she/he also decides the proportions of the two components, as defined by θ_{ih}. For example, in the case of health care the difference in the quality of the private and public good can be viewed in the form of increased waiting time, due to queueing or waiting lists patients are subject to for receiving care from the public sector, as opposed to a quicker access to treatment in the private sector (Blundell and Windmeijer 2000). Another example relates to inpatient care in the private sector, which offers patients more benefits, such as private rooms, enhanced facilities, better food, etc, compared to the public sector. Amongst factors affecting θ_{ih} can be household characteristics reflecting the opportunity cost of consuming the good in the public instead of the private sector (e.g. in the case of health care, foregone earnings or disutility from waiting before treatment) or the level of eligibility and/or take-up by household members. In the empirical analysis of this article θ_{ih} is estimated by comparing the behaviour of households with and without access to public provision: the more the publicly provided good is consumed by those entitled to it—other things being equal—the more they are predisposed to behave as if they were on a higher utility curve.

Writing $q^*_{ih} = q_{ih}(1 + \theta_{ih})$ the utility function becomes

$$U(q^*_{1h}, \ldots, q^*_{nh})$$

which is maximised subject to $\sum_{i=1}^{n} p_i q_{ih} \leq y_h$, where p_i is the price of private good i and y_h the total expenditure of household h, or equivalently subject to $\sum_{i=1}^{n} p^*_{ih} q^*_{ih} \leq y_h$, where $p^*_{ih} = \frac{p_i}{1+\theta_{ih}}$.[1]

It follows from duality theory that the above utility maximisation problem is equivalent to minimising

$$\sum_{i=1}^{n} p^*_{ih} q^*_{ih}$$

subject to $U(q^*_{1h}, \ldots, q^*_{nh}) \geq u_h$; or minimising the cost function

$$C(p^*_h, u_h) = C(p, \theta_h, u_h)$$

where $p^*_h = (p^*_{1h}, \ldots, p^*_{nh})'$, $p = (p_1, \ldots, p_n)'$ and $\theta_h = (\theta_{1h}, \ldots, \theta_{nh})'$. Thus the utility and cost functions[2] are of the form first given by Barten (1964), where public (free or at reduced charge) supplementation of a private good is introduced as a price subsidy, i.e. a scaling of the price of the corresponding privately purchased amount of the same good. The price scaling in this case is expected to be downwards, indicating that the more a household resorts to free of charge consumption of a particular commodity, the lower is the unit cost of this commodity.

In order to consider the behavioural and welfare implications of the public provision modelled above, we assume that consumer preferences are described by the Quadratic Logarithmic (QL) cost function, which is the most general functional form that allows recovery of the cost and welfare effects of changes in consumer behaviour (Banks et al. 1997; Lewbel 1990). The QL cost function is given by

$$\ln C(p^*_h, u_h) = a_h(p^*_h) + \frac{b_h(p^*_h) u_h}{1 - l_h(p^*_h) u_h} \tag{2}$$

where $a_h(p^*_h) = a_h(p, \theta_h)$, $b_h(p^*_h) = b_h(p, \theta_h)$ and $l_h(p^*_h) = l_h(p, \theta_h)$ are differentiable functions with respect to prices, p_i for all i. Moreover, $a_h(p, \theta_h)$ is homogenous of degree one in prices, whereas $b_h(p, \theta_h)$ and $l_h(p, \theta_h)$ are homogenous of degree zero. The utility of household h is denoted by u_h. Note that in (2) the dependency of the cost function on household characteristics can come through two channels: the parameters of the cost function and the household-specific price scaling associated with public provision.

[1] The time subscript t that can be attached to the variables in this section is omitted for notational simplicity.

[2] The relation between p_i and θ_{ih} is dictated by p^*_{ih}, hence $C(p, \theta_h, u_h)$ is not any arbitrary function of p and θ_h.

Consumer behaviour, as described by the Marshallian budget share for the ith commodity, is then obtained by differentiation of the log cost function with respect to $\ln p_i$,

$$w_{ih} = \frac{\partial a_h(p,\theta_h)}{\partial \ln p_i} + \frac{\partial \ln b_h(p,\theta_h)}{\partial \ln p_i}[\ln y_h - a_h(p,\theta_h)] + \frac{\partial l_h(p,\theta_h)}{\partial \ln p_i}\frac{1}{b_h(p,\theta_h)}[\ln y_h - a_h(p,\theta_h)]^2. \quad (3)$$

Once the parameters of (3) are known, welfare from public provision can be computed as the index

$$I_{h0} = \frac{C(p_h^*, u_0)}{C(p_0^*, u_0)} = \frac{C(p,\theta_h,u_0)}{C(p,\theta_0,u_0)} \quad (4)$$

where θ_0 is the price scaling corresponding to the reference household, for instance a household not eligible to free of charge consumption of the publicly provided private good under consideration. In this case (4) shows the compensation required by a household entitled to public provision to give up this entitlement, i.e. attain the same level of utility as a household without such entitlement.

Under the QL form of consumer preferences (4) becomes

$$\ln I_{h0} = a_h(p,\theta_h) - a_0(p,\theta_0) + \left[\frac{b_h(p,\theta_h)}{1 - l_h(p,\theta_h)u_0} - \frac{b_0(p,\theta_0)}{1 - l_0(p,\theta_0)u_0}\right]u_0 \quad (5)$$

and, normally, depends on the utility level of the reference household, u_0. This so-called 'base dependence' property is well known to hold true for all measures reflecting cost comparisons between households with different characteristics (Lewbel 1991) and implies that the magnitude of (5) is a function of some arbitrary normalisation (non-decreasing transformation) of u_0, unless $b_h(p,\theta_h) = b_0(p,\theta_0)$ and $l_h(p,\theta_h) = l_0(p,\theta_0)$ for all h.

3 Empirical model

In this section we first specify a rank-3 demand system defined by the QL cost function (Lewbel 1990), where public provision enters through the price scalar θ_h, as described above. It should be noted here that scaling in our analysis refers to the procedure used in modelling potential savings associated with public supplementation of private consumption, rather than the costs incurred by additional household members (Pollak and Wales 1981).

For the household-specific price indices in (2), the functional form corresponding to the QL Almost Ideal demand system (Banks et al. 1997) is used to obtain an empirical rank-3 demand system. In particular,

$$a_h(p_h^*) = \alpha_{0h} + \sum_i \alpha_{ih} \ln p_{ih}^* + 0.5 \sum_i \sum_j \gamma_{ij} \ln p_{ih}^* \ln p_{jh}^* \quad (6)$$

$$b_h(p_h^*) = \prod_i (p_{ih}^*)^{\beta_{ih}} \tag{7}$$

$$l_h(p_h^*) = \sum_i \lambda_{ih} \ln p_{ih}^*. \tag{8}$$

Equivalently, expressing (6)–(8) as functions of p and θ_h,

$$a_h(p_h^*) = a_h(p, \theta_h) = a_h(p) + \bar{a}_h(\theta_h) + g(p, \theta_h) \tag{9}$$

where $a_h(p) = \alpha_{0h} + \sum_i \alpha_{ih} \ln p_i + 0.5 \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j$, $\bar{a}_h(\theta_h) = -\sum_i \alpha_{ih} \ln (1+\theta_{ih}) + 0.5 \sum_i \sum_j \gamma_{ij} \ln(1+\theta_{ih}) \ln(1+\theta_{jh})$ and $g(p, \theta_h) = -0.5 \sum_i \sum_j \gamma_{ij} [\ln p_i \ln(1+\theta_{jh}) + \ln(1+\theta_{ih}) \ln p_j]$,

$$b_h(p_h^*) = b_h(p, \theta_h) = \frac{b_h(p)}{b_h(\theta_h)} \tag{10}$$

$$l_h(p_h^*) = l_h(p, \theta_h) = l_h(p) - l_h(\theta_h), \tag{11}$$

where $b_h(\theta_h) = \prod_i (1+\theta_{ih})^{\beta_{ih}}$, $b_h(p) = \prod_i (p_i)^{\beta_{ih}}$, $l_h(p) = \sum_i \lambda_{ih} \ln p_i$ and $l_h(\theta_h) = \sum_i \lambda_{ih} \ln(1+\theta_{ih})$. Then the Marshallian budget shares take the form

$$w_{ih} = \alpha_{ih} + \sum_j \gamma_{ij} \ln\left(\frac{p_j}{1+\theta_{jh}}\right) + \beta_{ih}[\ln y_h - a_h(p, \theta_h)] + \frac{\lambda_{ih} b_h(\theta_h)}{b_h(p)} [\ln y_h - a_h(p, \theta_h)]^2. \tag{12}$$

Integrability of (12) imposes the following restrictions on the parameters: $\sum_i \alpha_{ih} = 1$ all h, $\sum_i \gamma_{ij} = 0$ all j, $\sum_i \beta_{ih} = \sum_i \lambda_{ih} = 0$ all h for adding up; $\sum_j \gamma_{ij} = 0$, all i for homogeneity; and $\gamma_{ij} = \gamma_{ji}$ all i, j for symmetry.[3]

To retain the linearity of $\sum_j \gamma_{ij} \ln \frac{p_j}{1+\theta_{jh}}$, we define $\theta_{ih} + 1 = \exp(\sum_s \xi_{is} N_{sh})$, where ξ_{is} are parameters capturing the effect of household characteristics N_{sh}, relating to the perceived quality of the publicly provided good. Furthermore, health care is considered here to be the only publicly supplemented private good in the demand system, denoted by setting $\theta_{ih} = 0$ all i, except $i = M$. Therefore, and to simplify the notation, we drop the ith subscript and write $\theta_h + 1 = \exp(\sum_s \xi_s N_{sh})$. In the absence of price variation, and under the restriction of household invariance for some of the parameters of the cost function, i.e. $\beta_{ih} = \beta_i$ and $\lambda_{ih} = \lambda_i$ for all h, the demand system (12) can be written as

$$w_{ih} = \alpha_{ih} - \gamma_{iM} \sum_s \xi_s N_{sh} + \beta_i [\ln y_h - \alpha_{0h} - \bar{a}_h(\theta_h)] + \lambda_i b(\theta_h) [\ln y_h - \alpha_{0h} - \bar{a}_h(\theta_h)]^2$$

[3] The form of the budget share shows that even if the parameters of the cost function $\alpha_{ih}, \beta_{ih}, \lambda_{ih}$ are restricted to be free of h, violation of 'independence of base' can occur through the presence of θ_h in the coefficient of the quadratic term (Pashardes 1995).

where $b(\theta_h) = [\exp(\sum_s \xi_s N_{sh})]^{\beta_M}$ and $\overline{a}_h(\theta_h) = -\alpha_{Mh} \sum_s \xi_s N_{sh} + 0.5\gamma_{MM}(\sum_s \xi_s N_{sh})^2$. At this point it should be stressed that it is not necessary to have price variation to estimate welfare (income) effects in a rank-3 demand system (Pashardes 1995). Nevertheless, without price variation the model collapses to a system of Engel curves.

Given that without price variation the estimation of θ_h relies on the interaction between the level of expenditure, y_h, and the household characteristics N_{sh}, only a few ξ_s parameters can be estimated in the demand system above. For this reason we confine the investigation of the effects of age and income on household behaviour vis-a-vis the free public health care supplementation. The choice of age and income is motivated by economic theory (e.g. Grossman 1972), as well as by other empirical studies (e.g. Besley et al. 1999; Propper 2000) that demonstrate the impact of the above-mentioned variables on the demand for medical care. Moreover, due to the high correlation between age and income we introduce them in the demand system separately, in order to disentangle their effects on consumer behaviour relating to the public provision of health care. Thus, we define $\ln(\theta_h + 1) \equiv \phi_h = \sum_{s=1}^{3} \xi_s N_{sh}$ first as

$$N_{1h} = r_h, \quad N_{2h} = z_{1h} r_h, \quad N_{3h} = z_{1h}^2 r_h \tag{13}$$

where r_h is the number of persons in the household entitled to free public health care and z_{1h} is the age of household head; and then as

$$N_{1h} = r_h, \quad N_{2h} = \widehat{y}_h r_h, \quad N_{3h} = \widehat{y}_h^2 r_h \tag{14}$$

where $\widehat{y}_h$ is household's log net income, corrected for various characteristics of the household (number of children, rooms, cars, etc.) and its head (age, education, employment status, etc.). Alternative functional forms of ϕ_h, in z_{1h}, such as the linear and exponential were employed but were statistically dominated by the quadratic in nested and non-nested tests, respectively.[4]

The share equations are then given by

$$\begin{aligned} w_{ih} = {} & \alpha_{ih} - \gamma_{iM}\phi_h + \beta_i[\ln y_h - \alpha_{0h} + \alpha_{Mh}\phi_h - 0.5\gamma_{MM}\phi_h^2] \\ & + \lambda_i \exp(\beta_M \phi_h)[\ln y_h - \alpha_{0h} + \alpha_{Mh}\phi_h - 0.5\gamma_{MM}\phi_h^2]^2 \end{aligned} \tag{15}$$

and estimated for the specifications of ϕ_h given by (13) and (14).

Following standard practice in estimating demand systems from individual household data (e.g. Blundell et al. 1993), the household-specific intercepts of the budget share equations in (15) are defined as linear functions of observed characteristics of the household, $\alpha_{ih} = \alpha_i + \sum_{k=0}^{K} \alpha_{ik} z_{kh}$, for $i = 1, \ldots, n$, where $z_k, k = 0, \ldots, K$ are the characteristics of the household (such as the number of children, size of house, presence of central heating, availability of durables like cars) and its members (such as age, education, economic position and employment status). The parameter capturing

[4] In the presence of available information alternative variables can be used in defining ϕ_h, for example measures of health status and indicators about the take-up of publicly provided private goods.

the *subsistence* (zero utility) expenditure is defined as $\alpha_{0h} = \alpha_0 + \alpha_{01} z_{0h}$, where z_{0h} denotes the number of children in the (two adult) household.[5]

The interaction of parameters γ_{iM} and ξ_s, $s = 1, 2, 3$ captures commodity substitution due to access to the publicly supplemented private good. The household-specific parameters $\alpha_{Mh}\xi_s$ and $\gamma_{MM}\xi_s\xi_l$, $l = 1, 2, 3$, show the welfare (income) effect of this supplementation through scaled (Barten-type) prices.

Model estimation is conducted using nonlinear SUR under integrability restrictions, which in the case of system (15) become $\sum_i \alpha_{ih} = 1$, all h, $\sum_i \gamma_{iM} = 0$ and $\sum_i \beta_i = \sum_i \lambda_i = 0$. Furthermore, the restriction $\gamma_{iM} = \gamma$ for all $i \neq M$ is imposed to facilitate estimation that is conducted in the absence of price variation. This restriction implies that the substitution effects relating to public provision are the same in all share equations except in that of health care.

4 Empirical results

We estimate the effects of access to free public health care on consumer behaviour and welfare and investigate how these vary with the age of household head and the level of household income[6] using data drawn from the Cyprus Household Budget Surveys of 1996/1997 and 2003/2004.[7] Cyprus, like many non-western countries, does not have a universal National Health Service, although a large proportion of the population has free access to public health care. The health care system is mainly funded through general taxation.

Entitlement to free public medical care in Cyprus is largely means-tested, but is also provided to households with more than three children, individuals suffering from chronic life-threatening diseases, people with disabilities and civil servants and their

[5] The parameter α_0 is set equal to the log expenditure of the poorest 1% household in the sample. Also, the fact that the data used in the empirical analysis come from surveys conducted in two different periods (1996/1997, 2003/2004) is taken into account by introducing a dummy variable in α_{ih} and α_{0h}. The coefficient of the dummy variable in α_{0h} is set to 0.2, which is approximately the cost of living increase between the two periods. Moreover, with only two surveys, only two price observations are available, which are modelled by a dummy variable that captures price changes, but it cannot be interpreted as a price.

[6] Income (net of tax) consists of net salary and pension income, social security income (such as unemployment, sickness and child benefits), net income from rent, dividends and interest, income in kind, household own-consumption, imputed rent and pecuniary transfers from other households. Pecuniary transfers to other households are deducted.

[7] The Household Budget Surveys are usually conducted every 5 years by the Statistical Service of the Republic of Cyprus. Their main aim is to provide a detailed description of household consumption patterns so that the Consumer Price Index weights can be revised accordingly. Thus, the surveys collect data on households' expenditures, income, loans, investment and savings. Moreover, they contain information on household composition, household characteristics and amenities and a large number of demographic and socioeconomic characteristics of individuals. Information on the type of medical cover of the members of the households interviewed is contained only in the Surveys of 1996/1997 and 2003/2004. The samples consist of 2,644 and 2,990 households for the 1996/1997 and 2003/2004 Survey, respectively.

families.[8] Given the above eligibility criteria approximately 85–90% of the population is entitled to free or reduced cost public medical care. Nevertheless, public health services are poorly organised and of low quality (especially at primary level) so that the vast majority of households entitled to free health care also purchase health care services from the private sector. As a consequence the private health care sector in Cyprus is 'fully developed' at all levels (primary, secondary and tertiary) and accounts for around 52% of total health care expenditure in the country.[9] Based on data from the 1996/1997 and 2003/2004 household budget surveys, about 87% of households, all of whose members have access to free public health care, supplement public provision with out-of-pocket private purchases. Moreover, for households without entitlement to free public health care the mean yearly health care expenditure is 1,588 € and for households with all members eligible for free public medical care the corresponding figure is 804 €. Thus, even households eligible to free public medical care incur a non-negligible health care expenditure.

A demand system consisting of six commodity groups (food, clothing-footwear, health care, electricity-fuel, water-communication-other services and other non-durable goods) is estimated. The sample used in the empirical analysis consists of two-adult households whose age of head is between 20 and 60, not self-employed or employer and either does not have any or has only public/government medical cover (ditto for head's spouse).[10] This sample selection results in 711 observations and is motivated by the need to have demographic homogeneity amongst households. It should be noted here that the data identify the household members with government medical cover, i.e. with free access to public health care, but do not provide information on the take-up of this free service by those entitled to it. The summary statistics of the variables used in estimations are shown in Table 1.

Extending the sample to include other household categories, for example households with more than two adults and/or households with head age over 60,[11] will introduce further heterogeneity and necessitate the inclusion of additional parameters, i.e. equivalence scales for adult, and children in different age groups (Lewbel 1991; Pashardes 1995). In terms of medical cover we confined the sample to those entitled to free public health care and to those without any medical cover. The latter constitute the reference group allowing estimation of the benefit for those eligible for free government medical care. In-between cases in terms of medical cover were, therefore, excluded to avoid the introduction of extra parameters that complicates estimation and compromises robustness without also contributing to the main conclusions of the analysis. Of course, this approach implies that the empirical results may

[8] Free health care is provided to individuals with earnings less than 15,300 € per year or to households with income less than 30,600 € per annum (increased by 1,700 € for each dependant child). Individuals with earnings between 15,301 and 20,400 € and households with income between 30,601 and 34,400 € (plus 1,700 € for each dependant child) are entitled to public health care at a reduced rate.

[9] Details on the institutional setup of the Cyprus Health Care System can be found in Golna et al. (2004).

[10] Government medical cover allows the beneficiary to have access to free of charge (or in some instances at a very low cost) publicly provided health care services.

[11] It is well known that retired people have different behaviour patterns as consumers than the non-retired; hence it is common in empirical demand analysis to restrict the sample to households whose head is not retired (Blundell et al. 1993; Pashardes 1995).

Table 1 Summary statistics

Variable	Mean	SD	Min	Max
Shares				
Food	0.30	0.14	0	0.80
Clothing-footwear	0.11	0.07	0	0.37
Health care	0.07	0.08	0	0.68
Electricity-fuel	0.12	0.05	0.01	0.33
Services	0.30	0.12	0.05	0.80
Other goods	0.10	0.07	0	0.70
Household characteristics				
Number of children	1.37	1.08	0	3
Public medical cover (no. of members)	2.00	1.55	0	5
Number of rooms	5.55	1.43	1	12
Number of cars	1.38	0.63	0	3
Central heating	0.35	0.48	0	1
Head's characteristics				
Age	41.52	10.10	20	60
Private sector employee	0.64	0.48	0	1
Elementary education-not completed	0.04	0.19	0	1
Elementary education	0.23	0.42	0	1
Lower secondary education	0.09	0.29	0	1
Upper secondary education	0.40	0.49	0	1
College	0.09	0.28	0	1
University	0.14	0.34	0	1
Employed	0.83	0.38	0	1
Unemployed	0.05	0.21	0	1
Housewife	0.01	0.12	0	1
Chronically ill/disabled	0.04	0.19	0	1
Other				
Survey 2003/2004	0.45	0.50	0	1
Log income (deviation from min.)[a, b]	1.10	0.39	0	2.32
Log total expenditure[b, c]	8.97	0.52	7.22	10.56

Notes: [a] Income refers to annual net income corrected for various household and head characteristics and it is expressed in deviations from the minimum log income in the sample equal to 8.55
[b] It is reported in Cyprus pounds (1 Cyprus pound = 0.585274 €)
[c] Expenditure refers to annual consumption expenditure on non-durable goods and services included in the demand system

not hold for types of households substantially different from those in the selection considered.

Below we present the results obtained from SUR estimation of the scaling model given by the empirical specification (15), when the effects of public supplementation

depend on the age of household head or the level of household income.[12] In Table 2, we report selected parameter estimates that are of interest to the issues raised in this article, together with the corresponding t-ratios in parentheses. The remaining parameter estimates, which show the effect of household and head characteristics on the intercept of the share equations, are shown in the Appendix, which is available in the Supplementary materials. The computation of the t-ratios uses standard errors obtained from a heteroscedasticity-consistent covariance matrix estimation. The estimation of the heteroscedasticity-consistent covariance matrix incorporates a finite sample correction (MacKinnon and White 1985).[13] Table 2 also reports the root mean square error for each equation, the number of observations used, as well as the value of the objective function for the system.

The second and third column of Table 2 show the parameter estimates (t-ratios in parentheses) obtained from the scaling model (15) when the effects of public supplementation of health care depend on head's age and household income, respectively. The magnitude and significance of the estimated linear (β_i) and quadratic (λ_i) log expenditure parameters in the second column are very close to those of the corresponding estimates in the third column. The linear log expenditure effects are significant at 5% significance level, for all commodity groups, except for services. The significance of the quadratic log expenditure coefficient can be inferred from a test of $\lambda_i = 0$ and t-ratios show that the quadratic expenditure term is significant for electricity-fuel and only marginally significant for services.

For the specification which includes the head's age, the estimates of the scaling parameters (ξ_1, ξ_2, ξ_3) are individually (Table 2) and jointly (Table 3) significant. For the household income specification ξ_1, ξ_2 and ξ_3 are significant at 1% level, but all scaling parameters are jointly significant at 5% (Table 3). Thus, the joint significance in the income specification seems weaker than in the age model. The interactions of the scaling parameters with the coefficient of log expenditure in the health care share equation (β_M) are jointly significant at 10% level only in the age specification, indicating possible rejection of the independence of base hypothesis—the coefficient of the quadratic log expenditure term is not household invariant (Pashardes 1995). However, there is no sufficient evidence that the coefficient of log expenditure squared depends strongly on head's age (or household income) and the number of household members entitled to free public health care, as $\beta_M \xi_s$, $s = 1, 2, 3$, are jointly significant only at 10% level in one of the two specifications (Table 3).

[12] A health status variable could also be used in the specification of ϕ_h; however, this type of information is not usually available in household budget surveys. In the case of the Cyprus Household Budget Survey there is information on whether an individual is chronically ill/disabled but applies to a very small number of observations in the sample, and as a referee pointed out it does not capture the degree of severity of illness. Nevertheless, when the number of chronically ill/disabled individuals in the household is used the benefit for these households is very significant in certain specifications. This finding may not be very interesting since it applies to a very small fraction of the population; the results are available from the authors on request.

[13] Based on a modified Breusch–Pagan test (Greene 2003, p. 224) the null hypothesis of homoscedasticity is rejected for the shares of food and services. The White test (White 1980) rejects the null of homoscedasticity for the shares of food and other non-durable goods. The test results appear in the Appendix which is available in the Supplementary materials.

Table 2 Selected parameter estimates and system statistics

	Head's age	Household income
β_i		
Food	−0.0988 (−5.88)	−0.0958 (−5.20)
Clothing-footwear	0.0356 (3.77)	0.0398 (3.79)
Health care	0.0410 (3.82)	0.0396 (3.34)
Electricity-fuel	−0.0377 (−3.72)	−0.0347 (−3.08)
Services	0.0147 (1.09)	0.0092 (0.64)
λ_i		
Food	−0.0065 (−0.85)	−0.0087 (−0.99)
Clothing-footwear	−0.0012 (−0.23)	−0.0037 (−0.63)
Health care	−0.0064 (−1.18)	−0.0057 (−0.92)
Electricity-fuel	−0.0083 (−1.51)	−0.0105 (−1.67)
Services	0.0237 (3.00)	0.0280 (3.22)
ξ_1	7.8901 (3.68)	2.2893 (3.05)
ξ_2	−0.4127 (−3.68)	−3.3779 (−3.07)
ξ_3	0.0052 (3.66)	1.1427 (2.91)
γ_{iM}, all i except $i = M$	0.0019 (2.58)	0.0022 (1.87)
γ_{MM}	−0.0097 (−2.58)	−0.0109 (−1.87)
Root MSE		
Food	0.1077	0.1078
Clothing-footwear	0.0678	0.0677
Health care	0.0744	0.0750
Electricity-fuel	0.0470	0.0471
Services	0.1074	0.1074
Number of observations (N)	711	711
Objective* N	3,463	3,452

Table 3 Wald tests

Null hypothesis	Wald statistic and p-value	
	Head's age	Household income
$\xi_s = 0, s = 1, 2, 3$	13.65 (0.0034)	9.78 (0.0205)
$\beta_M \xi_s = 0, s = 1, 2, 3$	7.80 (0.0504)	5.42 (0.1435)
$\alpha_{Mk} = 0, k = 1, \ldots, K$	107.28 (<0.0001)	60.74 (<0.0001)
$\gamma_{MM} \xi_s = 0, s = 1, 2, 3$[a]	13.65 (0.0034)	9.78(0.0205)
$\gamma_{MM} \xi_1 = 0$	13.52 (0.0002)	9.31 (0.0023)
$\gamma_{MM} \xi_2 = 0$	13.55 (0.0002)	9.44 (0.0021)
$\gamma_{MM} \xi_3 = 0$	13.40 (0.0003)	8.44 (0.0037)

Note: [a] The inference about $\gamma_{iM} \xi_s = 0, s = 1, 2, 3, i \neq M$ follows from the outcomes in the table since the model is estimated under the restriction $\gamma_{MM} = -5\gamma$ and $\gamma = \gamma_{iM}$ for all $i \neq M$

The interaction of parameters $\gamma_{iM} \xi_s$ (all i, all s) relates to the demographic substitution effect in the share equations from changes in the number of household members entitled to free public medical care. In particular this effect is given by the minus of $\gamma_{iM}(\xi_1 + \xi_2 N_{2h} + \xi_3 N_{3h})$ (all i) and varies with head's age or with household income. For the age specification this effect is clearly significant as $\gamma_{iM} \xi_s$ (all i, all s) are both jointly and individually significant (Table 3). Moreover, the estimated effect in the health care equation is negative for ages 33–47 and positive otherwise, giving rise to a positive effect on average. This suggests that at equivalent expenditure, households with members entitled to free public health care when compared to similar households

Table 4 Estimated elasticities of demand with respect to budget

Commodity group	Head's age	Household income
Food	0.5868	0.5802
Clothing-footwear	1.3099	1.3087
Health care	1.4675	1.4550
Electricity-fuel	0.4952	0.4846
Services	1.1868	1.1920
Other goods	1.4566	1.4561

without such entitlement are found to favour health care over the other commodities, for ages of the head 20–32 and 48–60. The opposite occurs (they favour other commodities over health care) when household head is aged 33–47. The statistical significance of the substitution effect relating to the entitlement to free public health care is slightly weaker for the income specification. Nevertheless, the estimated effect in the health care equation appears to be negative for households in the middle to high deciles of the income distribution. The effect is positive for households in the lowest 47% and the highest 2% of the distribution.

The overall savings due to access to free public health care is more complicated to calculate since it involves the interaction of several parameters, as it can be seen from the terms in the square brackets of (15). We shall return to this point in the next section.

Table 4 reports the estimated budget elasticities computed from the two specifications.[14] The elasticities are computed for each household using the estimated parameters and the fitted values of the budget shares. The elasticities in Table 4 are the weighted average of individual household elasticities using as weights the share of each household to the total sample expenditure for the relevant commodity group (Banks et al. 1997). Food and electricity-fuel are perceived by consumers as necessities, whilst the remaining commodity groups are viewed as luxuries.

The impact of head's age and household income in modelling the benefit from publicly provided goods is investigated by estimating two separate systems of share equations. This is because, as known from demand analysis, without price variation the information basis for the estimation of differences in welfare (income) effects across households is limited (Pashardes 1995). However, to test which variable (head's age or household income) is more informative in modelling public provision of private goods, we estimate a single demand system including both head's age and household income in ϕ_h. In particular, the model is estimated for $\phi_h = \xi_1 r_h + \xi_2 r_h z_{1h} + \xi_3 r_h z_{1h}^2 + \xi_4 r_h \widehat{y}_h + \xi_5 r_h \widehat{y}_h^2$, and the significance of the two alternative sets of variables is tested. The results of Wald tests are shown in Table 5.

The hypothesis that the cost reduction (and the substitution effect) from access to free public health care does not vary with age (the effects of age and age square) is

[14] Budget elasticity for household h and commodity i is given by $\varepsilon_{ih} = \frac{\mu_{ih}}{w_{ih}} + 1$, where $\mu_{ih} \equiv \frac{\partial w_{ih}}{\partial \ln y_h} = \beta_i + 2\lambda_i \exp(\beta_M \phi_h)(\ln y_h - \alpha_{0h} + \alpha_{Mh}\phi_h - 0.5\gamma_{MM}\phi_h^2)$ and the second equality follows from equation (15).

Table 5 Wald tests, head's age versus household income

Null hypothesis	Wald statistic and p-value
$\xi_s = 0, s = 2, 3$	15.18 (0.0005)
$\xi_s = 0, s = 4, 5$	13.40 (0.0012)

clearly rejected. The hypothesis that the cost reduction (and the substitution effect) from access to free public health care does not vary with income is also rejected; thus, we cannot find evidence against either of the two specifications. This might mean that both variables are equally relevant in modelling benefits from public provision. Nonetheless, when they are separately used in modelling, age variables impact more significantly on consumer behaviour than income, as inferred from Table 3

5 Welfare implications

The empirical results discussed in the previous section have found entitlement to free public health care in a household to have an age or income dependant effect on consumer behaviour. To evaluate the welfare implications of these empirical findings we compute the expenditure required by a household (with at least one member) entitled to free public medical care to reach the same level of utility as the (reference) household whose members are not entitled to free public health care. At $u_0 = 0$, this expenditure index is given by

$$\ln I_{h0}^{S} = \alpha_{0h} + \overline{a}_h(\theta_h) - \alpha_{00} - \overline{a}_0(\theta_0) = -\alpha_{Mh}\phi_h + 0.5\gamma_{MM}\phi_h^2, \tag{16}$$

and can be seen as a measure of the compensation required by household h so that its members forego entitlement to free public health care. For households with members ineligible for free public health care $\theta_h = \theta_0 = 0$. These households are included in the empirical analysis as the reference group to allow estimation of the parameters in θ_h for households with free public medical care entitlement.

We also present the welfare analysis from an alternative model obtained by translating the cost function and we refer to as the 'translating' model.[15] The expenditure index derived from the translating model is given by

$$\ln I_{h0}^{T} = \alpha_{0h} + f_h - \alpha_{00} - f_0 = f_h, \tag{17}$$

where $f_h = \sum_{s=1}^{3} A_s N_{sh}$. Both indices, I_{h0}^{S} and I_{h0}^{T}, are computed for the definitions of N_{sh} variables given in (13) and (14), yielding results where the welfare implications vary with age and income. The comparisons in (16) and (17) are carried out for the same number of children and the same survey period for household h and the reference household (i.e. they differ only in the number of household members entitled to free public health care).

[15] The translating model is presented along with the corresponding estimation results in the Appendix which is available in the Supplementary materials.

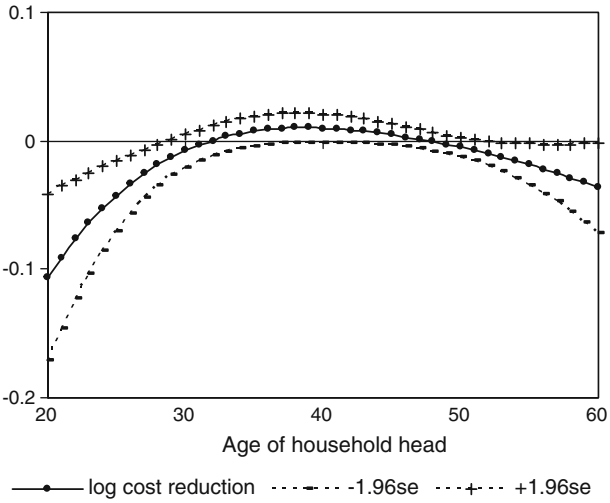

Fig. 1 Log cost reduction by age of household head, scaling model

Although the translating model is not theoretically motivated, it provides a simpler empirical specification than the scaling model analysed in the previous section, because it does not include higher order terms of the variables relating to public provision, r_h. This simpler model is often used in demand analysis for the estimation of adult equivalence scales (Pashardes 1995) and here can serve as a benchmark for investigating the robustness of the scaling model. Since scaling or translating the original demand system results in two non-nested models it is also investigated which model is more favoured by the data using a non-nested test (Davidson and Mackinnon 1982; Manera and McAleer 2005).

As the empirical evidence in favour of/against the age or income variables is not very clear, non-nested tests are conducted for models that include either the age or income variables. The null hypothesis that corresponds to the scaling (translating) model implies the restriction that the coefficients of the fitted values from the translating (scaling) model are all zero in all share equations estimated using the scaling (translating) model. In one instance the coefficients of the fitted values are allowed to differ in each share equation; thus, a Wald statistic for their joint significance is computed. Alternatively, a single coefficient is estimated, i.e. the same parameter for all share equations, hence a t-statistic is used to test for its significance. The results of both Wald tests and t-tests, with statistics that are virtually zero and the corresponding p-values that are nearly one, are inconclusive, as neither model can be rejected against the other. One possibility is that both models fit the data equally well, since they are very similar and essentially differ only in higher order terms that cannot be tracked by the data. In this case the power of the test to distinguish between the two models is rather small.

5.1 Variation with age

Figures 1 and 2 show the log cost (expenditure) reduction from access to free of charge public medical care by one household member, as estimated by the scaling and

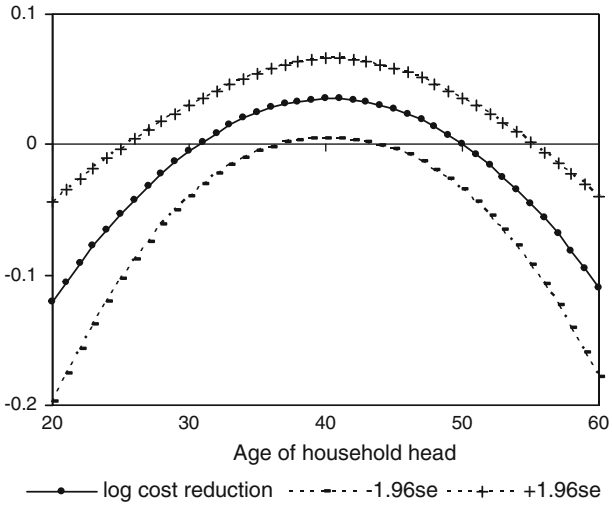

Fig. 2 Log cost reduction by age of household head, translating model

translating model, respectively. The estimated indices[16] reported in Figs. 1 and 2, whose corresponding functional forms are given in equations (16) and (17), are estimated for all ages of household head in the range 20–60. The upper and lower endpoints of the 95% confidence intervals are also shown, indicating the ages for which the log cost reduction is significantly different from zero. The standard errors used in the construction of the confidence intervals are obtained from a heteroscedasticity-consistent covariance matrix estimation.

It can be seen from Fig. 1 that log cost reduction is significantly different from zero (at 5% level) for head's age 20–28 and over 52, whereas for the remaining ages cost reduction is not so different. For example, a household whose head is 20 years old and one of its members has access to free public health care has a log cost reduction equal to 0.1, which means 10% lower expenditure than a household with the same characteristics but without free access to the same public services. For ages 32–47 entitlement to free public medical care appears to be associated with higher expenditure (compared to a household without such entitlement). However, this rather odd finding can be dismissed as statistically insignificant and attributed to the quadratic modelling, forcing the cost to increase before it comes down as age increases. From Fig. 1 it can be inferred that for households with heads aged 29–31 and 48–51 the benefit from their entitlement to free public health care is also insignificant; whereas, as mentioned earlier, this benefit is significant for households with heads aged 20–28 and 52 or older.

Figure 2 follows a similar pattern to Fig. 1, showing that a cost reduction from entitlement to free public health care is experienced by households whose head's age lies

[16] The index in Fig. 1 is computed at the sample averages of the variables in α_{Mh} (except for head's age) for the case where one household member is entitled to free public health care, i.e. he/she possesses government medical cover.

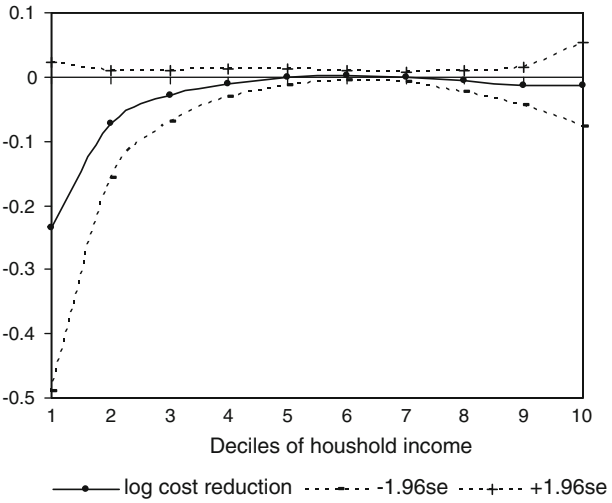

Fig. 3 Log cost reduction by decile of net household income, scaling model

in the tails of the age range 20–60. In particular the log cost reduction is statistically different from zero (at 5% level) for households with heads aged 20–25 and 56–60. For example, a household with one member entitled to public health care and whose head is 20 years old has about 12% lower expenditure than a household with the same characteristics except for the entitlement to free public medical care. For ages 31–50 the model suggests an increase in expenditure but this is not a statistically significant change. For ages 26–30 and 51–55 there appears to be a small cost reduction from entitlement to free public medical care, again, not statistically significant.

From Figs. 1 and 2 we can conclude that the two models[17] give similar results, namely that households with very young or older heads benefit significantly from entitlement to free medical care. The translating model results into more extreme values for cost reduction than the scaling model, in the sense that it suggests a larger benefit for households with younger and older heads. The average log cost reduction (over all ages) estimated from the two models is 0.016 and 0.017 for the scaling and translating model, respectively. Hence, the empirical findings from both models converge to the conclusion that for each member entitled to free public health care households enjoy, on average, a reduction of around 1.5–2% in their total consumption expenditure.

5.2 Variation with income

The log cost reduction from access to public health care per household member for different (net) income deciles is shown in Figs. 3 and 4, for the scaling and translating

[17] Both scaling and translating models were also estimated using three stage least squares (3SLS) to account for possible endogeneity of total expenditure. The results from 3SLS estimation are similar to those from SUR estimation, but 3SLS give slightly larger estimates for the benefit of the publicly provided private good. The results of 3SLS estimation are available from the authors on request.

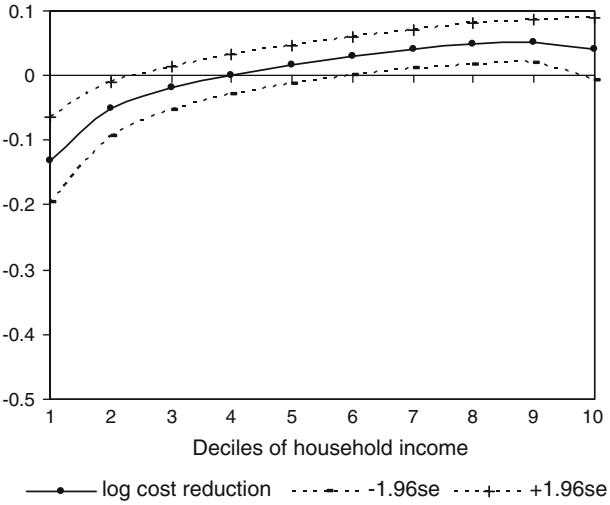

Fig. 4 Log cost reduction by decile of net household income, translating model

model, respectively. The deciles on the graphs are in ascending order, thus 1 corresponds to the lowest and 10 to the highest decile.[18] To indicate the deciles for which log cost reduction is statistically different from zero, the upper and lower endpoints of 95% confidence intervals are also plotted.

Figure 3 shows that for all income deciles the log cost reduction from entitlement to free public health care is not significantly different from zero, even though it tends to be larger for the lower (1st and 2nd) deciles. On the other hand, Fig. 4 shows a statistically significant log cost reduction for the lowest two net income deciles. For example, households in the lowest income decile with one member entitled to public health care have a benefit equivalent to 13% of their total expenditure. Households in higher income deciles (6th–9th) seem to experience a small increase in total expenditure from access to public health care. This result, significant at 5% level, is clearly paradoxical. A possible explanation is the quadratic modelling mentioned above; however, data limitations could not allow this to be investigated further.

Overall, Figs. 1, 2, 3, 4 and the outcomes of tests in Table 3 suggest that amongst Cypriot households the age of head appears to impact more on benefits associated with access to public health care than income.

6 Conclusion

The techniques in the literature for evaluating the welfare effects of publicly provided private goods such as health care include both revealed (e.g. indices for in-kind benefit valuation) and stated (e.g. contingent valuation) preference methods. This article

[18] Equations 16 and 17 are computed at the average $\widehat{y}_h$ in each decile. Also, in analogy to the index in Fig. 1, the index in Fig. 3 is computed at the sample averages of the variables in α_{Mh} (except for $\widehat{y}_h$) for the case where one household member is entitled to free public health care.

considers a revealed preference approach to estimating consumer welfare from free access to publicly provided private goods, using consumer demand analysis and readily available household survey data. The basic assumption of the proposed model is that free public provision can be combined with purchased quantities of the same good from the private sector.

Free public provision is considered as a household-specific affine transformation of the private good in question. This allows the unobserved consumption of the publicly provided (part of the) good to appear in the consumer demand system as a price scaling of this good. Then the behavioural effects of free public provision can be estimated as parameters of the demand system, with the corresponding welfare effects calculated as a money metric comparing the cost of achieving a given level of utility by consumers with and without access to free public provision.

An empirical investigation is provided in the case of health care services in Cyprus, where free public provision is not universal and most of those entitled to it supplement their consumption with purchases from the private health sector. The price scaling associated with free access to public health services is modelled as a function of the age of head and income of the household. Furthermore, in the empirical analysis the effect of free public provision on household cost is also investigated using an alternative empirical specification known in the literature as translating. Although not having a meaningful theoretical interpretation in the context of our analysis, translating can be a useful benchmark for comparison with scaling because the two models are observationally very close to each other.

The conclusion emerging from our empirical analysis is that amongst households entitled to free access to public health care only those with very young or older head and/or low income appear to have a statistically significant benefit from these services. This probably reflects low take-up by better off households and households with smaller health care needs, due to the low quality of the public health care services, including queuing and bureaucratic inconvenience. On average, the benefit from the entitlement of one household member to free public medical care in Cyprus is estimated to be around 2% of total household expenditure. These empirical results raise a question about the effectiveness of the state health care system in Cyprus.

The approach proposed in this article can be used for the estimation of the behavioural and welfare impact of means-tested access to free public provision in the case of goods other than health care. Examples include free access to goods and services (meals, transport, etc.) provided to certain household groups in different countries as part of policies aimed at reducing inequality and combating poverty. It can also be extended to goods for which supplementation is not allowed by the public provision scheme, as in education when either private or state schooling must be selected.

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