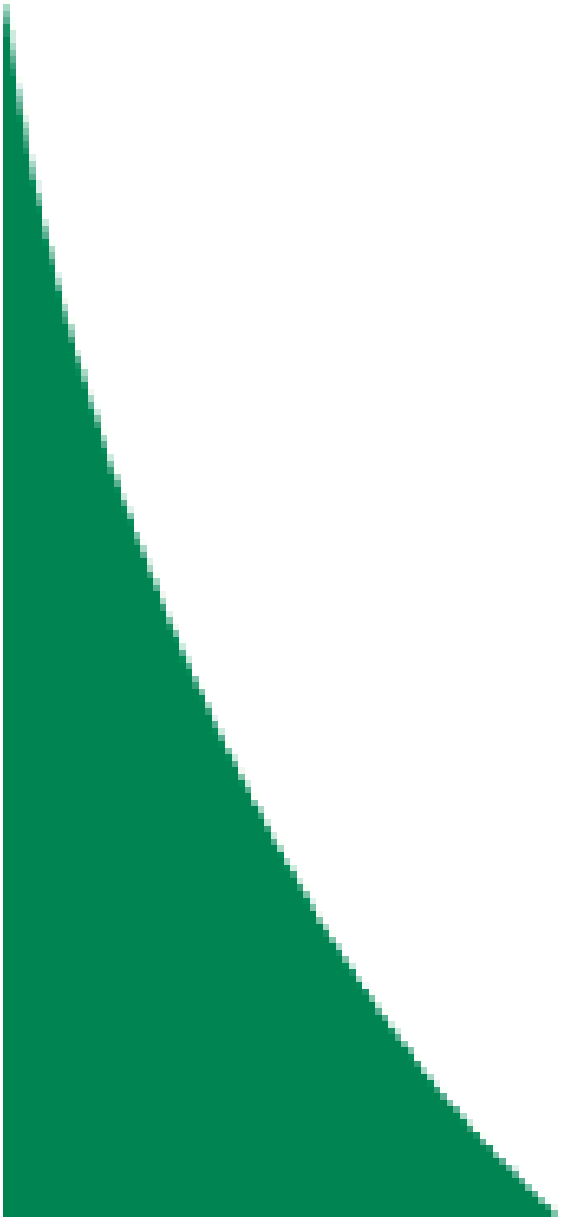

PRICE AND QUALITY IN THE UK CHILDCARE MARKET

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Abstract

Childcare subsidies are typically advocated as a means to making paid employment profitable for mothers, but also have important ramifications for the use and quality of paid childcare. Even if one is concerned primarily with the *quantity* aspect, the *quality* dimension cannot be ignored. This paper provides an exposition of the potential biases in estimates of price elasticities with respect to quantity that do not allow for quality variation or for the possibility of non-linear pricing structures. Using an approach developed in the demand estimation literature, a price measure addressing these issues is derived and the importance of using this measure is tested using British data. Price is found to have a negative impact on the use of formal paid care, the hours purchased and the quality chosen. However, failure to control for quality effects and non-linearities in the price measure is shown to generate significant overestimates of the price elasticities.

Keywords: childcare, unit values, quality

JEL classification: D12 J13

1 Introduction

The availability and cost of formal childcare has grown in importance in recent decades as increasing numbers of mothers have chosen to return to paid employment rather than undertake full-time care of their children. More recently, government policy in the UK and in the US has tended to take the line that formal employment rather than welfare support is the best means for families to escape poverty, particularly for families headed by single mothers. But there has also been a growing recognition that mothers will not and cannot work unless there is an alternative affordable source of care for their children. The recent policy debate has also emphasised the greater employability of mothers once their youngest child has reached school age and employment programs have been targeted towards this group. Hence, an analysis of the childcare market is particularly timely not only for pre-school children but also for younger school children.

Childcare subsidies have traditionally been viewed as one of the main approaches to making paid employment profitable for mothers, but the effects of such subsidies may be more wide-ranging than purely encouraging mothers to work.[1] Indeed, there is an expanding literature on the estimation of the impact of childcare price (and thereby subsidies) on childcare choices (use of paid care[2], type of care[3] and quality of care[4]), on mothers' employment participation[5] and hours of work[6] and on fertility[7]. For those primarily concerned with the quality of care provided to children and its' effect on child development, the response in terms of the use of formal childcare and the quality chosen may be the main objective of childcare subsidies. Yet even if one is not concerned explicitly with the impact of childcare subsidies on the quality choice, it is important not to ignore quality effects in estimating quantity elasticities. In addition,

[1] See Duncan & Giles (1996) for a discussion of the theoretical reasons for government subsidises in the childcare market.
[2] See Blau & Robins (1988), Hotz & Kilburn (1991), Michalopoulos, Robins & Garfinkel (1992), Ribar (1992, 1995) and Blau & Hagy (1998).
[3] See Hotz & Kilburn (1991), Hofferth & Wissoker (1992), Blau & Hagy (1998) and Michalopoulos & Robins (1999)
[4] See Berger & Black (1992), Michalopoulos, Robins & Garfinkel (1992), Hagy (1998) and Blau & Hagy (1998).
[5] See Blau & Robins (1988, 1989), Hotz & Kilburn (1991), Leibowitz, Klerman & Waite (1992), Connelly (1992), Berger & Black (1992), Ribar (1992, 1995), Jenkins & Symons (1995), Kimmel (1995, 1998), Averett, Peters & Waldman (1997) and Anderson & Levine (1999).
[6] See Heckman (1974), Michalopoulos, Robins & Garfinkel (1992), Duncan & Giles (1996) and Michalopoulos & Robins (1999).
[7] See Blau & Robins (1989).

previous work[8] has suggested that prices are non-linear with respect to the quantity of childcare purchased.

The initial part of this paper provides an exposition of the potential biases that may arise in estimates of price elasticities that do not allow for the possibility of quality variation or non-linear pricing structures. These issues have traditionally been approached in the literature by using a measure of mean price or cost within a geographically defined market in order to net out the quality and hours effects *within* a market. More recent work (such as in Blau & Hagy (1998) and Hagy (1998)) has combined this approach with factors believed to influence quality levels from provider surveys to remove quality effects *across* markets.

The main innovation is to apply a procedure developed in the demand estimation literature[9] to estimate a price measure that controls for both quality and quantity effects in the observed hourly childcare expenditure across markets using parameters estimated from within-market variation. In the absence of direct quality information, it is assumed that, within a market, individuals will only pay more for a better quality good and higher hourly expenditures are related to a set of characteristics that affect quality choice according to the theoretical model. The advantage of using this residual price parameter (rather than a direct cost measure such as childcare workers' wages) is that it captures all price variation regardless of the cause: as long as individual consumers act as price-takers, there is no need to differentiate between supply-side and demand-side sources of price variation.

The importance of using different measures of the price is tested by comparing the resulting estimates of price elasticities with respect to the use of formal childcare and the hours of care purchased for both pre-school and school children.[10] Failure to control for hours and quality in the price measure does not appear important for the estimated price elasticity for the propensity to use formal paid care for pre-school children, but omission of quality controls generates an *overestimate* of the elasticity for school children during term-time. Moreover, failure to control for hours and quality effects in the price measure leads to a significant *overestimate* of its impact on

[8] See Walker (1992) or Ribar (1995)
[9] As in Deaton (1987) or Crawford, Laisney & Preston (1999)
[10] Kimmel (1998) shows that the method used to construct a price for childcare can be important for the estimated price effects, but focuses on the definition of the dependent price measure, the choice of explanatory variables and the selection correction technique in predicting price rather than on the quality issue.

the hours of formal childcare used for both pre-school and school children. In addition, price is found to have a significant negative impact on the quality choice for both types of children.

The next section derives a theoretical model of quantity and quality choice in the childcare market, while section 3 summarises how childcare prices have been constructed in previous work. Section 4 describes a method for generating a price measure that controls for endogenous quality and hours choices and the results of applying it to British data is presented in section 5. Section 6 analyses the impact of the choice of price measure on estimated price elasticities, while the final section concludes.

2 Theoretical Background

A simple theoretical model is derived to illustrate the role of childcare quality choice in employment and childcare decisions. We assume that the fathers' or mothers' partners' labour supply is given, so that family utility is defined over consumption (C), the mother's leisure (L) and quality of childcare (Q). It is assumed that the mother has no preference between non-working hours spent caring for the children or spent in "pure" leisure without the children, allowing $L = T - H$ to be substituted into the utility function, where T is the total hours available to the mother and H is the mother's hours of work. However, this does not imply that the mother will spend all her non-working time with her children because the quality of non-maternal care may be better than maternal care. There are n children in the family requiring care. It is assumed, for expositional simplicity, that the number of children is treated as an exogenous parameter; that children are treated identically with respect to the type and quality of care chosen; and that the family cares about the quality of care per child relative to consumption and leisure.

There are three sources of childcare: maternal care, informal care (such as the father, relatives or friends) and formal care (such as childminders, nurseries or nannies). Total childcare quality depends upon the division of care between these sources and the relative quality of each type. In order to focus on the decision to use formal care rather than the division of care between mother and informal sources, the quality of maternal and informal care are assumed to be closely related and determined

exogenously by the mother's characteristics at some level denoted q_M. Similarity in these qualities does not seem unreasonable. For example, highly educated mothers are more likely to have highly educated parents themselves, and grandparents are an important potential source of informal care. Formal care is available at a variety of quality levels, denoted q, which reflect differences across different modes of care as well as heterogeneity within any particular type of care. Total childcare quality for each child is therefore a function of the given quality of maternal and informal care and the chosen hours (denoted F) and quality of formal care per child:

$$Q = Q[q_M, q, F]$$

Note that the contribution of formal care to total childcare quality does not enter as a single argument qF. This is to allow for the possibility that the marginal benefit from an hour of formal care of a given quality level will depend upon the level consumed. For example, initial hours in good nursery care may be considered extremely beneficial to a child's development, but the final hours of a very long day may be viewed as detrimental. Indeed, the case could be made that there are diminishing (or increasing) returns to all types of childcare, including the mother's care. Hours of formal care may be positively or negatively related to total childcare quality depending upon whether $q > q_M$ or $q < q_M$. If there is diminishing quality with the quantity consumed, increasing formal hours may switch formal care from being a relative "good" to a relative "bad".

The mother may face quantity constraints on the availability of informal and formal care, denoted $\overline{I}$ and $\overline{F}$ respectively. Since children must receive continuous care, these generate a time constraint on the relationship between the amount of formal care that can be chosen for each child and the mother's hours of work:

$$\overline{F} \geq F \geq \left(H - \frac{\overline{I}}{n} \right)$$

The first half of the constraint reflects the obvious point that formal care cannot exceed the amount available, which is assumed exogenous to the individual family's demands. On the other side, formal care must take up the slack between the mother's hours of work and the available informal care, which must be divided across the children. Because of the assumption that the mother is indifferent between non-

working hours spent caring for the children and those in pure leisure, this side of the constraint must bind if formal care is a bad (in the sense that $q < q_M$) and is used only to facilitate work. The data described below will show that some mothers may violate this constraint by working without using non-maternal childcare, but the ability to provide childcare whilst also working (perhaps by working at home) may be viewed as an alternative source of informal care and can be captured in the parameter $\bar{I}$.

Turning to the budget constraint, the hourly expenditure paid for formal childcare is termed the *unit value* (denoted V) and depends upon the chosen hours and quality of formal care as well as local market conditions. It is assumed that the childcare *price* consists of a scalar price level Π, which varies across markets and a relative price structure for quality and hours of care $r[q, F]$, which is fixed across markets[11]. The unit value is therefore defined as:

$$V = \Pi . r[q, F]$$

where variation in the price level Π reflects heterogeneity in the "hedonic" price for a standard level of quality and hours within a given market. It is assumed that higher quality costs more, implying that the function r is strictly increasing with respect to q. The choice variable of hours of care is included as a determinant of the unit value to allow for the possibility of economies of scale in the production of care or for variation in demand conditions at different hours. For example, there may be fixed costs involved in enrolment or changing marginal costs in the supply of inputs. No assumption is made a priori about whether the hourly payment falls or rises with hours, although it is assumed that the total cost rises with hours.

Finally, some types of childcare may offer a discount for multiple children from the same family. For example, there may be fixed costs in dealing with families that generate economies of scale with respect to the number of children. This would lead to a negative relationship between the price Π and the number of children n. However, it seems reasonable to assume that any such family discount would be sufficiently small to ensure that the total cost for a family ($n\Pi$) for given hours and quality will always rise with the number of children.

[11] The assumption of fixed relative prices for quality is common in the estimation of household demands systems, allowing the group of childcare inputs to be treated as a Hicks aggregate (see Deaton (1987) or Crawford, Laisney & Preston (199)). It is also assumed in Blau & Hagy (1998).

The constraints for $\overline{F}$ and $\overline{I}$, however, have obvious effects. Raising the amount of available formal care increases both the likelihood of using formal care and the amount used, while increases in the availability of informal care or fewer children requiring care has the opposite effect. The constraint also implies that the optimal hours of work have a positive relationship with the availability of both types of care and a negative correlation with the number of children.

Finally, the model as it stands suggests that q_M and q may be substitutes and negatively related in the sense that mothers with higher quality maternal and informal care may purchase lower quality formal care in order to achieve some *absolute* level of total childcare quality. But this is contrary to intuition: those providing better care informally may be more concerned that their children receive good quality care in formal settings or may have different perceptions about the benefits of formal care. For example, highly educated mothers may provide better care, be more concerned about the quality of care or believe pre-school nursery education is more important than mothers with lower levels of education. Hence, the *relative* quality of formal to informal care may be important and the two qualities may be complements. In terms of the model, this implies a positive correlation between high quality maternal care and a high marginal utility with respect to childcare quality, generating a positive relationship between q_M and q.

The derivation of this model has highlighted the factors important in determining childcare choices. More importantly, it has shown that consideration of the quality dimension in childcare makes the direction of the impact of changes in the external parameters difficult to predict. Hence, the analyst must rely on empirical investigation to determine the effect of price subsidies, but this first requires an accurate measure of the childcare price.

3 Measures of Childcare Price Used in Previous Work

3.1 Estimation Issues

Much of the research on the impact of childcare prices has used data from household surveys which typically record information on work behaviour, whether paid childcare is used, the hours of childcare and total childcare expenditure. Measurement of a price from this type of data must confront two problems. First, there is a selection

issue that the hourly expenditure is only observed for those using paid care and will therefore be truncated on the basis of price. Second, assessment of the potential impact of a childcare subsidy requires data containing variation in the price Π rather than heterogeneity in the unit value $\Pi.r[q,F]$. Indeed, the estimated response of some variable x to changes in the unit value relates to the true price derivative in the following way:

$$\frac{dx}{dV} = \frac{\frac{dx}{d\Pi}}{\left(r[q,F] + \frac{dV}{dq}.\frac{dq}{d\Pi} + \frac{dV}{dF}.\frac{dF}{d\Pi}\right)}$$

The estimate is unbiased only if quality and hours are at the average level ($(r[q,F]=1)$) and the quality and hours choices do not change with the price, that is, $\left(\frac{dq}{d\Pi}=0\right)$ and $\left(\frac{dF}{d\Pi}=0\right)$. If there is heterogeneity in the choice of quality or hours, but the quality and hours choice do not alter with the price, the measured elasticity will be unbiased for the average quality and hours chosen. However, it will be biased upwards for those choosing cheaper quality and hours combinations $\left(r[q,F]<1\right)$ and biased downwards for those choosing more expensive combinations $\left(r[q,F]>1\right)$. Intuitively, given the fixed relative price structure, a change in the price level has a smaller impact on the unit value for those choosing less expensive options so that any behavioural response is smaller than for those choosing more expensive options. However, if quality or hours respond to changes in the price, the measured *average* elasticity will be biased. For example, if quality moves positively with price, the change in the unit value will overstate the change in price and underestimate the responsiveness of any dependent variable. On the other hand, if quality is negatively related to price, the elasticity will be overstated.

The following three subsections summaries how the selection, quality and hours issues have been addressed previously in the literature.

3.2 Selection into Paid Care

An initial problem confronting users of household surveys is that the expenditure on childcare can only be recorded for children in paid care and is often only recorded for

those with working mothers. Hotz & Kilburn (1991) are almost unique[14] in using a data source which does contain information on childcare expenditures for both working and non-working mothers in the US and find "clear evidence that the child care demands of households with working mothers are selectively different from the population of all households with pre-school age children"(page (i)).[15] Most subsequent research using childcare expenditure data for working mothers has addressed this by including selection adjustment terms from a bivariate probit model for participation in work and for the use of paid care into the childcare price regression (see Connelly (1992), Michalopoulos, Robins & Garfinkel (1992), Ribar (1995)).

3.3 Quality Controls

It is rare for information on the quality of childcare to be collected in large household surveys. In response, some studies have simply used observed childcare expenditures (Michalopoulos, Robins & Garfinkel (1992)), while others have predicted expenditures using household variables (Hofferth & Wissoker (1992), Connelly (1992), Berger & Black (1992), Averett, Peters & Waldman (1997), Anderson & Levine (1999)). Using predicted expenditures controls for quality variations within the groups defined by the household variables, but not for differences between these groups. Other research has used geographical rather than individual variation in childcare expenditures based on regional or site averages (Blau & Robins (1988, 1989)) which, similarly, controls for within-region quality heterogeneity but does not allow for quality differences across areas. In all of these cases, the resulting price variation is generated by heterogeneity both in the price and in the quality choice.

Other analysts have combined household survey data with other sources of data or information at the regional level in order to control for quality differences. Some studies have included in the price regression measures of childcare regulations determined at the state or province level (Hotz & Kilburn (1991), Michalopoulos & Robins (1999), Kimmel (1998), Ribar (1992, 1995). But if such regulations affect the market price for childcare, they do so by altering the quality of care and a price

[14] Blau & Robins (1989) also use average weekly childcare cost per child by site for working and non-working married mothers from the EOPP 1980.

equation should control for these factors rather than using them as a source of variation. Other work has focused on the cost side and used regional data on wages (Ribar (1992), (1995)) or childcare worker wages (Blau & Robins (1988), Leibowitz, Klerman & Waite (1992)[16]) to capture variation in the childcare price, but these measures capture only supply-side variation ignoring potentially counter-balancing demand conditions. Moreover, in studies that use both these cost measures and a host of demographic variables in the price regression (Jenkins & Symons (1995)[17], Kimmel (1998)), the resulting price measure is capturing both quality differences and price heterogeneity.

In another strand of the literature, research has used data from surveys of childcare *providers* to estimate the relationship between observed childcare quality and the *cost* of supplying that quality (Powell & Cosgrove (1992), Mocan (1995), Mocan (1997)). The results from these studies are useful for evaluating the potential cost of providing a certain standard of care, perhaps through public provision, but are silent on the impact of market price on the quality chosen. However, Walker (1992) and Blau & Mocan (1999) utilise *fee* information from provider surveys to estimate quality-controlled prices that reflect both the demand and supply side of the market. These pieces shed considerable light on the shadow prices for different quality attributes, but do not consider the impact of prices on the demand for quantity or quality of childcare. Blau & Hagy (1998) and Hagy (1998) also use fee information from provider surveys to generate a price for each local geographic site, but then combine these prices with household survey data matched by site. The price is estimated as the site-specific intercept in a regression of hourly fee on factors capturing quality attributes. The approach used in this paper is conceptually similar to this work in using price variation across geographic regions which controls for quality differences across regions, but uses a single data source from a household survey.

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[15] The importance of this selection issue has been questioned by Kimmel (1998) who points out that, although "care must be taken when attempting to predict the hourly price of care for nonworking mothers... ...it is possible that these nonworking mothers utilize a type of child care that they themselves would not utilize were they to work." (page 290).

[16] In the piece by Leibowitz, Klerman & Waite, variation in the maximum childcare tax credit by state, time and predicted household income is also used to estimate the impact of a subsidy on work choices.

[17] Jenkins & Symons (1995) also use a measure of LA nursery provision to capture potential differences in the price resulting from the demand side of the market.

3.4 Non-Linear Pricing Structures

Little attention has been paid to the possibility that hourly prices may change with the hours of childcare purchased. Walker (1992), using data from provider surveys, finds that the hourly fee is concave in hours of care, reaching a maximum in the range of 60-64 hours per week. Ribar (1995), using household survey data, finds that total childcare expenditure increases at a decreasing rate with hours of *work* and different unit values are subsequently used in the estimation for full time and part time work. However, the unit value measured as expenditure per hours of *work* rather than hours of *childcare* (also used in Connelly (1992), Jenkins & Symons (1995), Kimmel (1998) and Anderson & Levine (1999)) may introduce additional bias into the estimated impact of the price. Consider the case where the quality and hours choices have no impact on the unit value so that $V = \Pi$, but the "unit value" is measured as childcare expenditure per hour worked ($V = \frac{\Pi F}{H}$). The estimated derivative with respect to the "unit value" relates to the true price derivative in the following way:

$$\frac{dx}{dV} = \frac{\frac{dx}{d\Pi}}{\left(\frac{F}{H} + \Pi.\left(\frac{1}{H}\frac{dF}{d\Pi} - \frac{F}{H^2}\frac{dH}{d\Pi}\right)\right)}$$

In general, the estimated elasticity is only unbiased if the hours of work and hours of childcare are constant and equal.

4 Estimation of the Childcare Price

4.1 Data

The estimation uses data from the Family Resources Survey (FRS), an annual cross-section survey of around 25,000 British households each year. The survey collects a wide range of data on employment status, family circumstances and income levels, as well as asking detailed questions about childcare use for each child in the family. One drawback of the data is that childcare information is collected consistently only for working mothers and the estimation is restricted to this group. Five years of FRS data are analysed: 1994/5, 1995/6, 1996/7, 1997/8 and 1998/9. The selected sample consists of "pre-school" children and "school" children with working mothers. "Pre-school" children are defined as those under the age of five and *not* in full-time

education, while "school" children are defined as those aged four to eleven and in full-time education. Very few school children above the age of eleven receive any type of childcare in the FRS data, consistent with the prior that children of this age do not normally require adult supervision outside of school hours. Children with mothers who are on maternity leave, are over 59 years old, or have missing wage or childcare information are excluded. The final sample consists of 5,604 pre-school and 12,306 school children, drawn from 11,446 mothers, of whom 2,797 have only pre-school children, 6,648 have only school children and 2,001 have at least one of each. For working mothers, information is collected on the type of childcare used for each child in the form of selecting one or more childcare options. For each child, questions are then asked about the total (over all types used) weekly hours of care and the total (over all types of care) weekly expenditure, separately for term-time and holidays. In addition to the FRS data, local authority statistics on childcare availability of day nurseries, playgroups, childminders, after-school clubs and holiday clubs are also used to capture possible supply-side constraints on the use of formal care. These are matched with the children in the FRS data by local authority and year.[18]

Positive childcare expenditures are occasionally reported for the use of "informal care" (with friends or relatives), but prices are only estimated for those using only formal modes of care[19] for two reasons. First, it is unclear how informal payments are determined in what is likely to be a non-market relationship. Second, most policy interest is in formal types of care. For children using a mixture of formal and informal care, the information that they use formal care is retained but the hours and expenditure data is not used. The distinction between different types of formal care is generally ignored, implicitly assuming that any price variation between different forms of care reflects differences in quality levels.

A comparison of the use of paid formal care in term-time and holidays is presented in table 1, highlighting a major dichotomy in behaviour between pre-school and school children. The use of formal care only during term-time rises with age for pre-school children and then declines with age for school children. Use during only the holidays is slightly higher for school children relative to their pre-school counterparts, but is

[18] Summary statistics for the data sample are available in appendix table B1.A full description and analysis of the childcare information in the FRS data and the local authority statistics is provided in Duncan, Paull & Taylor (2000a).
[19] Including childminders, nurseries, playgroups, nannies, after-school and holiday clubs.

not nearly as important as term-time use for either group. Most pre-school children who are in formal care during the term and holidays pay the same hourly cost for both periods, while most school age children face a higher hourly cost during term.

Table 2 presents the mean weekly hours of formal paid care and mean hourly expenditure by child's age. Again, there are important distinctions between pre-school and school children and between term-time and holiday usage. Weekly hours decline with age for pre-school children, although more notably for term usage than during holidays, while hours for school children, although substantially lower during term, exhibit a greater consistency over age (with the exception of 4-year-olds during term). Hourly expenditure declines with age for both pre-school and school children, but is notably higher for the shorter hours of care during term for school children than the corresponding holiday cost.

4.2 Econometric Model

The data contains only measures of the unit value (total expenditure divided by total childcare hours) rather than observations of the childcare price and quality. In order to recover the latter, we follow an estimation procedure similar to that developed in the demand estimation literature as in Deaton (1987) and in Crawford, Laisney & Preston (1999). This procedure assumes that consumers reside within identifiable regional clusters of households, with relative prices within a group fixed everywhere but differing by a linear factor between the spatial clusters. This corresponds to the earlier definition of the unit value for childcare, where relative prices over quality and quantity $r(q,F)$ are fixed across all markets (clusters) but a scalar element Π is allowed to vary between markets (clusters). Hence, the unit value is defined as:

$$V = \Pi.r[q,F]$$

The cluster or geographic market can be thought of as an area with distinct supply factors (such as local wage levels or rents) or demand conditions (such as the competitiveness of the market). Since consumers of formal childcare are assumed to be price-takers who cannot individually influence this price, the specific source of the differences in Π is not important. Indeed, one of the strengths of this approach is that the price reflects variation in both demand and supply factors rather than concentrating purely on cost measures.

Following Crawford, Laisney & Preston, selecting an approximate Almost Ideal Demand System with a log-linear approximation to the log price index, permits the unit value equation for household h in cluster C to be written as[20]:

$$\ln V^h = a_0 + aZ^h + b\ln F^h + \ln \Pi^C + v^h$$

where Z^h is a vector of household characteristics thought to influence the quality choice, v^h an idiosyncratic household effect and a_0, a and b are parameters. It is assumed that there are no unobserved cluster effects independent of the childcare price effect. This assumption has several important implications. For example, it encompasses the restriction that the price of all other goods does not vary systematically with the childcare price across clusters. In addition, it rules out the possibility that variation in tastes across regions may generate correlations between the choice variables that are independent of price. Note that the constant term a_0 is the part of price common across all clusters and $\ln \Pi^C$ the additional part specific to the cluster. Hence we are interested in obtaining a measure of $a_0 + \ln \Pi^C$ for each cluster or childcare market.

The estimation method proceeds in three stages. In the first step, we address the issue that the unit value is only observed for those who use paid care by estimating a selection adjustment term using a probit regression for the probability of using formal care. This selection adjustment term (λ) is then included in a second step unit value regression to control for selection into paid care.

In the second step, the parameters a and b are estimated consistently using within cluster variation in Z^h and F^h. Forming cluster means of the unit value equation including the selection adjustment term with the parameter c generates:

$$\overline{\ln V}^C = a_0 + a\overline{Z}^C + b\overline{\ln F}^C + c\overline{\lambda}^C + \ln \Pi^C + \overline{v}^C$$

Subtracting these cluster means from the original equation generates the second step regression:

$$\ln V^h - \overline{\ln V}^C = a(Z^h - \overline{Z}^C) + b(\ln F^h - \overline{\ln F}^C) + c(\lambda - \overline{\lambda}^C) + (v^h - \overline{v}^C)$$

[20] This corresponds to equation (3.3) in Crawford, Laisney & Preston (1999), where the good G subscripts have been suppressed and the quantity variable Q replaced by the number of childcare hours. The time effect has also been removed because year dummies were insignificant in the unit value regression after indexation.

In the third step, the price Π^C can now be estimated using the predicted parameters from the second step in a rearranged cluster means equation:

$$a_0 + \ln \Pi^C + \bar{v}^C = \overline{\ln V}^C - \hat{a}\bar{Z}^C - \hat{b}\overline{\ln F}^C - \hat{c}\bar{\lambda}^C$$

Since we have assumed that there are no unobserved cluster effects correlated with the childcare price, the term $\bar{v}^C$ is only random noise in the price measure. In addition, as we would like the price measure at average household characteristics for the sample (denoted $\bar{Z}^s$) and hours of childcare (denoted $\overline{F}^s$) rather than at their zero values, the price is estimated as:

$$a_0 + \ln \Pi^C = \overline{\ln V}^C - \hat{a}\bar{Z}^C - \hat{b}\overline{\ln F}^C - \hat{c}\bar{\lambda}^C + \hat{a}\bar{Z}^S + \hat{b}\overline{\ln F}^S + \hat{c}\bar{\lambda}^S$$

Effectively, the price is estimated for each cluster controlling for average hours of childcare, the average level of factors that affect the quality choice and the selection effect.[21]

In order to compare the impact of including selection, hours and quality controls in the price measure, four different measures were constructed. The first measure is the raw unit value mean for each cluster:

$$\ln price1 = \overline{\ln V}^C$$

The second adds the selection correction term:

$$\ln price2 = \overline{\ln V}^C - \hat{c}\bar{\lambda}^C + \hat{c}\bar{\lambda}^S$$

The third includes the selection correction term and adds the hours controls:

$$\ln price3 = \overline{\ln V}^C - \hat{b}\overline{\ln F}^C - \hat{c}\bar{\lambda}^C + \hat{b}\overline{\ln F}^S + \hat{c}\bar{\lambda}^S$$

The final measure includes the selection correction term and hours controls and adds the quality controls to generate our final price measure:

$$\ln price4 = \overline{\ln V}^C - \hat{a}\bar{Z}^C - \hat{b}\overline{\ln F}^C - \hat{c}\bar{\lambda}^C + \hat{a}\bar{Z}^S + \hat{b}\overline{\ln F}^S + \hat{c}\bar{\lambda}^S$$

[21] Steps 2 and 3 are econometrically equivalent to Blau & Hagy (1998) and Hagy (1998) who estimate the price as the site-specific intercept in a regression of hourly fee on factors capturing quality attributes.

Finally, two different measures of the quality choice for each household can be estimated using the $price4$ measure (since attempting to estimate quality with a price that does not control for quality would not be sensible). Rearranging the unit value equation for the household, the first quality measure is obtained using:

$$q_1^{\,h} = aZ^h + v^h = \ln V^h - b \ln F^h - \ln price4$$

Intuitively, this is a residual measure of the variation in unit value that cannot be attributed to variation in price or hours of childcare. However, it attributes all variation in the unit value correlated with hours to a non-linear price structure and ignores the possibility that the quality choice may be related to hours. A second quality measure is therefore considered which captures the other extreme of assuming that the price structure is linear with respect to hours:

$$q_2^{\,h} = aZ^h + b \ln F^h + v^h = \ln V^h - \ln price4$$

Intuitively, this is a residual measure of the variation in unit value that cannot be attributed to variation in price.

4.3 Regression Specification

Perhaps the most important specification decision is that of the boundaries of the clusters or childcare market. Ideally we would like to define the local childcare market by geographic area (proxied by local authority), year and the age of the child, as these are factors that may reasonably be thought of as influencing demand and supply conditions in the market. This presumes that opportunities for arbitrage by consumers across markets are limited, which certainly seems reasonable for the year and child's age. The potential for arbitrage across local authorities may be greater (particularly in local authorities of small geographical size such as in London), but this requires either relocation of place of residence or longer travelling time with the child to the childcare facility, either of which could generate sizable costs mitigating against widespread arbitrage.

However, limited sample size generates a trade-off in the number of market groups that can be used. More markets mean greater variation in the predicted prices, but reduce the cell size for each market price being estimated. For households in clusters with no unit value observation (zero cell size), a price cannot be predicted and a

fraction of the sample would be lost in subsequent estimation using the predicted prices. Consequently, the robustness of the results was tested across four different, increasingly broad, definitions of the market. Group 1 defines the market by LA, child's age and year. Group 2 defines the market by LA and child's age, combining the data across years. Group 3 defines the market by LA and "broad age", combining the data across children aged 1 to 3 and aged 4 to 5 for pre-school children and across ages 4 to 6 and 7 to 11 for school children. Finally, group 4 defines the market across LA alone, but still separately for pre-school and school children. In addition, the results from each group were tested imposing a minimum cell size of 10 for the unit value observations, but the imposition of this minimum for groups 1 and 2 was found to leave very small samples that could not be used practically. The chosen preferred specification is group 2, because it allows a reasonable proportion of the sample to be used while also creating a substantial number of markets, both for childcare choices during term-time and during the holidays.[22] However, key results are also presented for the other three groups and from the data imposing the minimum cell size for groups 3 and 4.

As previous work has shown that equation specification can be an important factor in explaining differences in estimated labour supply elasticities, we are careful to explain and justify our choice of explanatory variables.[23]

The first step probit for the use of paid care includes variables influencing the constraint $\overline{F} \geq F \geq H - \frac{\overline{I}}{n}$ as well as the exogenous parameters q_M, w, Y and p. The amount of non-maternal care needed is captured in n by the number of pre-school children and in the number of young school age (under 11) children in the family and in H, measured directly as the mother's weekly hours of work. The number of pre-school children also affects whether the family can afford to use paid care, as n also enters the budget constraint. The availability of unpaid care, $\overline{I}$, is reflected in whether the mother works at home, whether she has a partner, whether the partner is working,

[22] Appendix table B2, available from the authors, presents these sample use and cell size trade-offs between the different groups.

the number of older (aged 12-18) children in the household, the number of families in the household and the number of years at the current address (capturing the development of informal networks of help). The availability of formal care for pre-school children, $\overline{F}$, is reflected in the statistics on the number of day nursery places, playgroup places and the childminder places per 10,000 population by Local Authority and year. For school children, the number of childminder places, after-school clubs and holiday clubs per 10,000 population is used to capture availability of formal care outside of school hours.

Three variables are included which could influence both the level of informal care available ($\overline{I}$) and the quality of maternal care (q_M). Mother's age and education may affect the quality of maternal care, but could also influence the availability of unpaid care as older or more educated mothers may be less likely to live near their immediate family. Ethnicity may capture the degree of extended family ties and thus influence the availability of informal care. In addition, it might also be included in the relative quality of informal care with an unpredictable direction of influence. For example, non-native speakers may derive additional benefit from formal care where the child has greater opportunities to learn the native language. On the other hand, such a child may derive less benefit from formal care if the child simply feels uncomfortable amongst speakers of a different language.

The explanatory variables also include other factors determining the ability to afford paid care: the mothers' earnings (wH) and other family income (Y). As the mothers' hours of work already enter in the need for care dimension, the earnings variable is reflecting the effect of the hourly wage. Finally, factors influencing the price Π are included in the first step probit, including the age of child and local authority dummy variables for the group 2 estimation.[24] [25]

[23] Kimmel (1998) conducts several robustness checks to compares her results with Connelly (1992) and Ribar (1992). The analysis finds that the selection technique is unimportant in the results and that the choice of price measure has some impact, but equation specification is the most important factor. The section concludes that "much of the variation in child care price elasticity estimates across papers in the literature is likely due to equation specification. This suggests that researchers in this field must be very careful to explain their selection of variables to include in the various equations, and conduct sensitivity analyses to determine the importance of the specification chosen." (page 293).

[24] Year dummies were also included for the group1 estimation and the child age dummies excluded for the group 4 estimation.

[25] The exclusion restrictions for the first step participation probit consist of the mothers' work hours, the availability of unpaid care variables and the LA availability of paid care variables.

In the second step price regression, the dependent variable is total expenditure on childcare divided by the number of hours for each child using paid care. The vector of household characteristics thought to influence the quality choice include the mother's age, education and ethnicity which capture potential impacts on the quality of maternal care and thereby the quality choice for paid care. The number of pre-school siblings, the mother's earnings and other family income are included to capture the ability to afford higher quality care. As discussed above, the unit value may vary by the number of children requiring care, either due to price discounts for multiple siblings from the same family or due to quality choice differences. Direct measures of the weekly hours of care are also included in the regression. As already stated above, non-linearities in price with respect to childcare hours may partially or completely reflect changing quality choices. Hence, their inclusion in the unit value regression may provide additional quality control, but their impact must also be interpreted with caution.

5 Results

5.1 First Step Selection Into Paid Care

The results of the first step probit regression are presented in table 3a for pre-school children and in 3b for school children. Most of the variables enter in a significant manner in the expected direction and are fairly consistent across both pre-school and school children and across term-time and holidays.

Increases in the mother's work hours have an important positive impact on the use of paid care, with a larger estimated impact for holidays than term-time. The size of the effect also declines as hours increase. Not surprisingly, a mother who works at home is much less likely to use paid care. The availability of informal care within the household through a partner, especially a non-working partner, reduces the likelihood of use, as does the presence of older children, especially for school children. However, other families at the same address do not significantly reduce the probability of use. Potential outside sources, proxied by years at current address, also appear important.

Older mothers are more likely to use paid care for pre-school children, even controlling for potential income effects. Those with higher levels of education are also

more likely to choose to pay for formal care, but only during term-time. During the holidays, there is a marked increase in use for mothers who left full-time education after age 16, but little differentiation in behaviour between latter education leaving ages. This suggests that older and more educated mothers have less informal care available or perceive the benefits of formal care to be greater or, contrary to popular impression, do *not* provide higher quality informal care than younger and less educated mothers. Being a member of an ethnic minority reduces the probability of using paid care, especially for pre-school children, suggesting either greater informal sources of care or lower benefits from formal care for this group.

The local authority measures for the availability of formal care do not, in general, enter in a significant manner. Only the level of playgroup availability has a marginally significantly positive impact on the use of formal care for pre-school children, while the availability of holiday club places appears to increase term-time use for school children. Given the presence of the dummy variables for local authorities in the regression, the impact of these local authority measures are estimated from the time-series variation within each authority across the five years of the data and it is not surprising that there are few significant results. Hence, although this cannot be taken as evidence that there are no supply side constraints limiting the use of paid care, we do not find any evidence that such constraints exist.

For pre-school children, the number of other pre-school and school siblings has an important negative impact on the propensity to use formal care, suggesting that the number has greatest impact on the ability to afford paid care rather than on whether informal sources can provide sufficient care for all the children. For school children, only the number of school siblings has a significant effect, possibly indicating that pre-school children have counter-balancing effects of both reducing the resources available to pay for care and of drawing-in informal sources of childcare support. The ability to pay for formal care as measured in the mother's earnings and other family income is an important factor in its use. Even though the mother's hours of work has been controlled for, the size of the effect of the mothers' earnings is a large multiple of the effect from other sources of family income, suggesting possible implications for models of income-pooling and intra-household allocation of resources.

For pre-school children, the likelihood of using paid care increases until the age of two and then declines. Recalling that the sample is premised on working mothers, this may reflect a correlation between the age of child when a mother returns to work and the availability of informal sources of care, rather than the type of path a child might follow as it ages. For school children, use of formal care consistently falls with the child's age, in line with the declining use of any type of care, formal or informal, as the child becomes more independent. These patterns across the child's age for pre-school and school children may either *generate* differential childcare market conditions by age of child or *reflect* differential conditions and prices. In either case, they are suggestive that markets can reasonably be determined by the child's age. In addition, the local authority dummy variables enter with joint significance in the regression, showing significantly different propensities to use paid care across the geographic areas designated as separate childcare markets.

5.2 Second Step Unit Value Regressions

The results of the second step price regressions are presented in table 4a for pre-school children and 4b for school children. The hours control regression is the regression used in the estimation of $price3$, while the hours and quality controls regression is used for $price4$ and the coefficients for the regression with only the selection term (for $price2$) is reported in the notes to the tables.

The unit value declines with the hours of childcare at a very similar rate regardless of whether quality controls are included or not. The size of the decline is similar across pre-school children during term and the holidays and school children during term, but is higher for school children during holidays. This provides strong evidence either that there are non-linearities in the pricing structure with respect to hours or that the quality choice declines significantly with the number of hours.[26]

The age of the mother has no impact on the unit value, but mothers with the middle levels of education tend to pay more. This may indicate that these types of mothers value the benefits of good quality paid care the most highly or that the lowest and highest qualified groups provide high quality maternal and informal care, reducing the need to supplement childcare quality with good quality paid care. Ethnic minorities

[26] How much of this decline may be due to switches between different types of childcare at different hours levels is investigated as an aside in table 5 below.

tend to pay a lower unit value, but this is only slightly significant for pre-school children during term. In general, more pre-school or school siblings reduce the unit value, with the exception of the number of pre-school siblings for school children during term. This may reflect either a declining ability to afford higher quality care when there are more children or price discounts for multiple children from the same family. Although previous work using provider surveys has evidenced sizeable discounts for multiple children from the same family (for example, see Walker (1992)), our data does not permit a division between the two competing explanations and it is assumed that the effect is due to quality rather than discounts to err on the side of caution in estimating price variation. As expected, the mother's earnings and other family income allow a higher quality choice for those who can afford it for pre-school children, although, as with the probability of using paid care, the mother's earnings has a much larger impact than other sources of family income. For school children, these income factors appear to be less important, although mothers' earnings still have a significant positive impact on the unit value during term time.

The coefficient on the Mills ratio in the regressions without quality controls suggest that children who use paid formal care pay a lower hourly expenditure than would those who do not use the care. However, once the quality controls are included, the selection effect is no longer significant except in the case of school children during term time where there is a significant positive effect, suggesting that those who use paid care pay a higher hourly expenditure than would those who do not use it.

As an aside, table 5 presents regressions for the unit value with the hours variable interacted with the mode of formal childcare used in order to test whether the non-linearity differs by childcare type.[27] For pre-school children during term, the decline in unit value with hours is significantly greater for childminders and the "other" category than for multiple types of formal care and day nurseries/playgroups. During holidays, the rate of decline is significantly slower for the day nursery group than all of the other three groups. For school children, there are no significant differences between the types of care. Nevertheless, there is a significant decline in unit value as hours increase within each type of childcare, showing that the decline evidenced

[27] Regressions, which also included the quality control variables, produced qualitatively identical results for the childcare hours variables to the regressions shown.

across the aggregated hours in tables 4a and 4b may be due to changes within childcare type as well as possibly to switches between types.

6 Price Effects on Childcare Choices

The impact of price on the choices of whether to use paid care and the hours of paid care was estimated using the four different price measures. As already mentioned, this estimation is restricted to children with working mothers and caution should therefore be exercised in extending the specific behavioural conclusions to the wider population of all mothers. In addition, the mother's hours of work are taken as fixed[28] and it should be recognized that there may be additional significant second round effects through employment responses. On the other hand, the results highlight the potential impacts of childcare subsidies even in the absence of any labour supply reactions.[29] Indeed, such an approach may be desirable if childcare choices are considered more flexible than employment decisions. For example, employment conventions may restrict flexibility in work hours or it could be argued that work choices are based on longer-term dynamic issues while childcare is determined by shorter-term considerations.

Considering the probability of using paid care first, tables 6a and 6b each present the coefficients and standard errors for the price variable from a total of 28 separate probit regressions. Each regression also included the variables shown in tables 3a and 3b with the exception of the child age and local authority dummy variables, but the coefficients on the variables not shown were qualitatively unchanged by the replacement of the child age and local authority dummy variables with the price regressor.

For pre-school children, using the preferred group generates significant negative price elasticities across all price measures for term time and holidays. Inclusion of the selection term and the hours controls considerably increases the elasticity, while the quality controls tend to reduce the size of the price effect. This suggests that failure to control for hours is understating the impact of any price change, which could occur if

[28] This corresponds to model 3 in the appendix with H determined exogenously.

[29] For example, abstracting from labour supply issues could also be useful in analysing the improved childcare subsidy in the Working Families Tax Credit (WFTC), where, even in the absence of any employment effects, the subsidy may have considerable impact both on the cost of the program and on childcare quality. Most analysis of the impact of the WFTC has ignored potential childcare effects and considered only employment effects under current childcare arrangements. For example, see Blundell, Duncan, McCrae & Meghir (1999).

the price and hours of care are negatively related and if the price declines with childcare hours. As shown above, failure to control for the hours effect under these circumstances makes the variation in price appear greater than it really is, leading to an understatement of its impact. In addition, failure to control for quality overstates the price effect; a situation that can arise if quality is negatively related to price. But the two effects are counter-balancing for pre-school children: the differences between the coefficients for the price 2 and price 4 measures are not significant. Turning to the results for the alternative market groups shown in the second row, the pattern in the magnitude of the elasticities across the price measures is robust to the choice of market group. However, for two of the alternatives, including quality controls in the price measure generates an estimated price elasticity that is no longer significantly different from zero and is significantly different from the price 2 estimate in one case. For school children, the price measures created using the preferred group generate only two moderately significant elasticities during term-time, while adding quality controls in the price measure turns a significant negative elasticity into an insignificant positive elasticity. This pattern is repeated across the alternative groups, the only exception being the most narrowly defined market group 1. Hence, the evidence suggests that the combined failure to control for hours and quality in the price measure does not generate a significant bias in the estimated price elasticity for pre-school children due to the counter-balancing impact of the hours and quality effects, but the omission of quality controls alone generates an *overestimate* of the price elasticity for school children during term-time.

Regressions estimating the impact of price on the hours of formal childcare included the same set of additional regressors as the use probit, with the exception of the local authority availability measures on the assumption that the hours are unaffected by the number of places once a place is obtained. Naturally enough, the hours of care are closely related to the mother's hours of work, but other factors drive considerable variation around the work hours.[30] As in the case of the propensity to use any formal care, whether the mother works at home, whether she has a partner and whether he is working or not, and the number of older children in the family all have a significant negative influence. Counter-intuitively, the number of other families in the household increases the hours used for pre-school children during the holidays and for school

children during term time. Mothers' education is most important in raising hours for school children during term. The effect of pre-school and school siblings is also similar to that for the use of care: increasing numbers of either significantly reduce the hours used with the exception of the number of pre-school siblings for school children during term. Finally, mothers' earnings have a large positive impact on hours, while other family income has a smaller positive impact.

Tables 7a and 7b are analogous to tables 6a and 6b, showing the price elasticities for hours of care across the different price measures and market groups. For pre-school children, there is a significant negative relationship between hours of care and price when the raw price (price 1) or selection corrected price (price 2) measures are used with the preferred group 2. But adding hours and quality controls to the price measure generates a significant reduction in the size of the elasticity to an estimate that is no longer significantly different from zero. This pattern is repeated with some of the alternative groupings. For the most narrowly defined market (group 1), the significance of the negative elasticity is maintained with hours and quality controls in the price measure, but there is still a significant reduction in the size of the elasticity when these controls are added. The groups with the minimum cell size produced no significant elasticities at all. The pattern is almost identical for school children, although the magnitude of the reduction from adding hours and quality controls is even higher than for pre-school children. Hence, there is strong evidence that failure to control for hours and quality effects in the price measure leads to a significant *overestimate* of its impact on the hours of formal childcare used for both pre-school and school children. This may not be surprising: if either the price declines with hours or if poorer quality is chosen at higher hours, there will be a spurious negative correlation between the observed hourly expenditure and the hours purchased due to the hours choice driving the price outcome rather than the reverse direction of causation.

Tables 8a and 8b present the results from regressions for the two quality measures for pre-school and school children respectively. In addition to the price 4 measure, the regressions also include the quality control variables used in the unit value regressions. The quality of care tends to decline with the price, a result which is

[30] The impact of the non-price regressors using the selection-corrected price measure (price 2) for the preferred group 2 is available from the authors in appendix table B3.

generally stronger for the second quality measure, which assumes that unit value variation over hours reflects changes in the quality choice rather non-linearities in the price structure. The price effect is greatest for pre-school children during the holidays and smallest for school children during the holidays, but is of a very similar magnitude for pre-school and school children during the term time. Mother's age is only significant for the second quality measure for pre-school children, exhibiting a positive effect on quality at younger ages and a negative impact at older ages. There is a tendency for mothers with the middle levels of education to choose higher quality, while children from ethnic minorities use poorer quality according to the second quality measure. Both the numbers of pre-school and school siblings reduce the quality choice for pre-school children, while only school siblings tend to influence the quality level for school children. Mothers' earnings are positively related to the quality choice according to the first quality measure for pre-school children and for school children during term time only, while other family income has a positive impact for pre-school children and according to the second quality measure for school children. It is interesting to note that although mothers' earnings generally have a larger impact than other family income, the discrepancy for the quality choice is not as large as it was for the use and hours of formal care.

The impact of price on quality was also examined using the different market groups.[31] For pre-school children, using the most narrowly defined markets (group 1) generates a smaller but more precisely estimated elasticity, which is still significantly negative, while no significant relationship is found with any of the more broadly defined market groups. For school children, the most narrowly defined market again generates a smaller elasticity, but only for the first quality measure, while the broader markets (groups 3 and 4) without a minimum cell size lead to larger significantly negative elasticities. Hence, there is evidence that higher prices lead to a lower quality choice, but this conclusion is not consistent across the choice of market specification.

7 Conclusions

This paper has developed a simple theoretical model of hours and quality choices in the childcare market in order to show how conventionally used measures of childcare

[31] Appendix table B4, available from the authors, presents the coefficients and standard errors on the price coefficient from the 28 quality regressions across the market groups.

price may generate biased estimated price elasticities. It has drawn on an empirical approach used in the demand estimation literature to derive a price measure that allows for the possible dependence of the observed unit value (hourly expenditure) on the endogenous childcare hours and quality choices. Using data from the British Family Resources Survey, the importance of applying the proposed method is tested by comparing the impact of using different price measures on the estimated price elasticities for the use of formal paid care and the hours of care.

The findings show that price has a negative impact on the decision by working mothers to use formal paid care and on the hours they purchase. In addition, the evidence suggests that price is negatively related to quality. Hence, price subsidies could potentially increase childcare expenditures both through increasing the quantity demanded and by raising the level of quality purchased. Only the former is likely to be related to labour supply changes on the part of mothers while the latter will still raise the cost of any subsidy program. The analysis also shows that the propensity to use formal paid care and the hours of care are dependent upon the availability of unpaid informal alternatives, on the mothers' age and education, on the number of children in the family and the ability to afford paid care in the form of the mothers' earnings and other family income. The unit value tends to decline with the hours of care for all types of formal care, due either to a non-linear price structure with respect to hours or to lower quality being chosen at higher hours of care. The choice of quality of care is also dependent upon the mothers' age and education, ethnicity, the number of pre-school and young school siblings, mothers' earnings and other family income. These results suggest how childcare outcomes might be influenced by the particular design of a childcare subsidy. For example, targeting childcare support to lone mothers who have greater need for formal care or providing financial support through mothers' earnings rather than general family income may generate a larger response per pound spent. The next step, however, is to combine the development of an accurate measure of childcare price and modelling in the childcare market with the employment dimension.[32]

The analysis also shows that the choice of price measure is of considerable importance in estimating price effects. Failure to control for hours and quality in the price measure does not appear important for the estimated price elasticity for the

propensity to use formal paid care for pre-school children, but omission of quality controls generates an *overestimate* of the elasticity for school children during term-time. Moreover, there is strong evidence that failure to control for hours and quality effects in the price measure leads to a significant *overestimate* of its impact on the hours of formal childcare used for both pre-school and school children. However, comparisons with alternative specifications show that these conclusions are subject to the choice of boundaries for the independent childcare markets.

In summary, this paper has shown that quality choices and non-linear pricing structures should not be ignored in research estimating childcare price elasticities. Moreover, it has suggested an approach addressing these issues that may be applied with a single household survey data source. The estimation results have highlighted how childcare subsidies may have important impacts on the use of formal childcare and the chosen quality of that care even in the absence of any labour supply effects. Such outcomes are important not only for program cost but also for the greater social concern of the welfare and development of the next generation of children.

[32] This next step is taken in Duncan, Paull & Taylor (2000b)

References

Anderson, P.M. and Levine, P.B. (1999), 'Child Care and Mothers' Employment Decisions', NBER Working Paper No. W7058.

Averett, S. L., Peters, E. H. and Waldman, D. M. (1997), 'Tax Credits, Labor Supply and Child Care', *Review of Economics and Statistics*, 79, 125-135

Berger, M. C. and Black, D.A. (1992), 'Child Care Subsidies, Quality of Care, and the Labor Supply of Low-Income Mothers', *Review of Economics and Statistics*, 74, 635-642

Blau, D.M and Hagy, A. (1998), 'The Demand for Quality in Child Care', *Journal of Political Economy*, 106, 474-481

Blau, D.M and Mocan, H.N. (1999), 'The Supply of Quality in Child Care Centers', NBER Working Paper No. W7225.

Blau, D. M. and Robins, P.K. (1988), 'Child-Care Costs and Family Labor Supply', *Review of Economics and Statistics*, 70, 374-381

Blau, D. M. and Robins, P.K. (1989), 'Fertility, Employment and Child Care Costs', *Demography*, 26, 287-299

Blundell, R., Duncan, A., McCrae, J. and Meghir, C. (1999), 'The Labour Market Impact of the Working Families Tax Credit', mimeo, Institute for Fiscal Studies

Crawford, I., Laisney, F. and Preston, I. (1999), 'Estimation of Household Demand Systems using Unit Value Data: An Approach Allowing More General Engel Curves', mimeo, Institute for Fiscal Studies, January

Connelly, R. (1992), 'The Effects of Childcare Costs on Married Women's Labour Force Participation', *Review of Economics and Statistics*, 74, 83-90

Deaton, A. S. (1987), 'Estimation of Own and Cross-Price Elasticities from Household Survey Data', *Journal of Econometrics*, 36, 7-3

Duncan, A. and Giles, C. (1996), 'Should We Subsidise Pre-School Childcare, and If So How?', *Fiscal Studies*, 17, 39-61.

Duncan, A., Paull, G. and Taylor, J. (2000a), 'Patterns of Childcare Availability and Use and Mothers' Employment in 1990s Britain', mimeo, Institute for Fiscal Studies, December

Duncan, A., Paull, G. and Taylor, J. (2000b), 'Mothers' Employment and Use of Childcare in the United Kingdom', mimeo, Institute for Fiscal Studies, December

Hagy, A. P. (1998), 'The Demand for Child Care Quality', *Journal of Human Resources*, 33, 683-710

Heckman, J. J. (1974), 'Effects of Child Care Programs on Women's Work Effort', *Journal of Political Economy,* 82, 136-163.

Hofferth, S. and Wissoker, D. (1992), 'Price, Quality and Income in Child Care Choice', *Journal of Human Resources*, 27, 70-111

Hotz, V.J. and Kilburn, M. R. (1991), 'The Demand for Childcare and Childcare Costs: Should We Ignore Families with Non-Working Mothers?', NORC/University of Chicago Discussion Paper 91-11, Chicago:Illinois

Jenkins, S. P. and Symons, E. J. (1995), 'Child Care Costs and Lone Mothers' Employment Rates: UK Evidence', ESRC Research Centre on Micro-Social Change Working Paper 95-2, University of Essex

Kimmel, J. (1995), 'The Effectiveness of Child-Care Subsidies in Encouraging the Welfare-to-Work Transition of Low-Income Single Mothers', *American Economic Review Papers and Proceedings*, 85

Kimmel, J. (1998), 'Child Care Costs as a Barrier to Employment for Single and Married Mothers', *Review of Economics and Statistics*

Leibowitz, A., Klerman, J. and Waite, L. (1992), 'Employment of New Mothers and Child Care Choice', *Journal of Human Resources*, 27, 112-134

Michalopoulos, C., Robins, P. and Garfinkel, I. (1992), 'A Structural Model of Labour Supply and Child Care Demand', *Journal of Human Resources,* 27, 166-203.

Michalopoulos, C. and Robins, P. K. (1999), 'Employment and Child-Care Choices in Canada and the United States', mimeo, MDRC & University of Miami

Mocan, N. H. (1995), 'Quality Adjusted Cost Functions for Child Care Centers', *American Economic Review Papers and Proceedings*, 85, 409-413

Mocan, N. H. (1997), 'Cost Function, Efficiency and Quality in Day Care Centers', *Journal of Human Resources*, 32, 861-891

Powell, I. and Cosgrove, J. (1992), 'Quality and Cost in Early Childhood Education', *Journal of Human Resources*, 27, 472-484

Ribar, D.C. (1992), 'Child Care and the Labor Supply of Married Women: Reduced Form Evidence', *Journal of Human Resources*, 27, 134-165

Ribar, D.C. (1995), 'A Structural Model of Child Care and the Labor Supply of Married Women', *Journal of Labor Economics*, 13, 558-597

Walker, J. R. (1992), 'New Evidence on the Supply of Child Care', *Journal of Human Resources*, 27, 40-69

Table 1: Use of Formal Paid Childcare by Age of Child

% in each type by age	Never Use	Term time only	Holidays only	Term time and Holidays			
				Same hourly cost	Term costs more	Holidays cost more	Missing cost
Pre-school children							
0	69.2	3.5	0.1	21.9	0.3	0.8	4.4
1	64.8	3.7	0.2	23.9	0.7	0.7	6.1
2	63.3	5.0	0.2	23.6	0.8	0.7	6.5
3	65.6	5.7	0.2	18.4	2.8	1.3	6.0
4	70.8	5.5	0.0	14.8	2.7	0.9	5.3
School children							
4	78.7	4.1	1.6	4.6	6.5	1.7	2.8
5	81.6	4.2	1.7	3.1	5.5	1.4	2.5
6	84.8	3.8	1.8	1.8	4.0	1.7	2.1
7	84.4	4.3	1.9	1.8	4.0	1.5	2.1
8	86.9	3.9	1.8	1.4	3.2	1.2	1.7
9	88.8	3.2	1.2	1.4	2.7	1.2	1.5
10	90.4	2.8	1.0	1.1	2.1	1.0	1.7
11	94.1	1.7	1.4	0.4	1.6	0.1	0.7

Table 2: Mean Weekly Hours and Mean Hourly Expenditure for Formal Paid Childcare by Age of Child

Age of Child	Mean Weekly Hours		Mean Hourly Expenditure	
	Term time	Holidays	Term time	Holidays
Pre-school Children				
0	32.7	32.4	2.38	2.42
1	31.0	31.5	2.21	2.23
2	29.5	30.2	2.15	2.16
3	29.3	30.4	2.19	2.10
4	24.3	27.9	2.11	1.94
School children				
4	16.8	31.7	2.63	1.91
5	11.8	30.2	2.26	1.79
6	11.2	30.6	2.27	1.70
7	12.0	31.5	2.25	1.65
8	10.7	28.5	2.18	1.71
9	9.7	29.0	2.14	1.62
10	9.9	30.3	2.23	1.65
11	10.3	30.6	2.12	1.32

Notes: Mean values are for those using paid formal childcare.

Table 3a: Probit Regression for Selection Into Paid Formal Care: First Step for Price Estimation: Pre-school Children

Dependent variable: probability use formal paid care	Term time		Holidays	
	coeff.	s.e.	coeff.	s.e.
Need for care:				
mother's work hours	0.022***	0.008	0.030***	0.008
(mother's work hours)^2	- 0.000***	0.000	- 0.000***	0.000
Availability of unpaid care:				
mother works at home	- 0.443***	0.127	- 0.499***	0.139
partner	- 0.386***	0.075	- 0.359***	0.076
partner not working	- 0.311***	0.081	- 0.205**	0.082
# of older children in household	- 0.168**	0.070	- 0.284***	0.075
# of families in household	- 0.113	0.080	- 0.082	0.080
years at current address	- 0.018**	0.007	- 0.016**	0.008
Availability and/or quality of unpaid care:				
mother's age	0.150***	0.041	0.179***	0.042
mother's age^2	- 0.002***	0.001	- 0.002***	0.001
mother's education				
left full-time education age 17-age18	0.317***	0.048	0.273***	0.049
left full-time education age19-age21	0.644***	0.067	0.393***	0.067
left full-time education age 21+	0.902***	0.077	0.309***	0.075
ethnic minority	- 0.338***	0.089	- 0.219**	0.089
LA availability of paid care:				
day nursery places per 10,000 pop	0.155	0.294	0.462	0.309
(day nursery places per 10,000 pop)^2	- 0.035	0.156	- 0.213	0.172
dummy for missing # nursery places	0.125	0.147	0.111	0.150
play group places per 10,000 pop	- 0.124	0.185	- 0.191	0.184
(play group places per 10,000 pop)^2	0.069*	0.040	0.066*	0.039
dummy for missing # play group places	- 0.093	0.191	- 0.053	0.190
childminder places per 10,000 pop	0.196	0.533	- 0.039	0.533
(childminder places per 10,000 pop)^2	- 0.179	0.274	- 0.049	0.275
dummy for missing # childminder places	- 0.221	0.271	- 0.188	0.269
Need for care / can afford care:				
# of pre-school children in family	- 0.345***	0.046	- 0.324***	0.046
# of young school-age children in family	- 0.286***	0.035	- 0.406***	0.037
Can afford paid care:				
ln (mother's weekly earnings)	0.651***	0.051	0.606***	0.051
ln (other weekly family income)	0.154***	0.025	0.150***	0.025
Price:				
child aged 0	- 0.325***	0.070	- 0.292***	0.070
child aged 1	- 0.160***	0.059	- 0.114*	0.059
child aged 3	- 0.079	0.058	- 0.092	0.059
child aged 4	- 0.136**	0.069	- 0.173**	0.071
LA dummies	included	included	included	included
Constant	- 6.991*	0.777	- 7.235***	0.782
Sample size	5604		5578	
Pseudo R^2	0.278		0.247	

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. 26 observations in 1 local authority were not used in the holiday probit because no child used paid formal care during the holiday within the local authority. Figures are for market group 2.

Table 3b: Probit Regression for Selection Into Paid Formal Care: First Step for Price Estimation: School Children

Dependent variable: probability use formal paid care	**Term time**		**Holidays**	
	coeff.	**s.e.**	**coeff.**	**s.e.**
Need for care:				
mother's work hours	0.029***	0.007	0.041***	0.007
(mother's work hours)^2	- 0.000***	0.000	- 0.000***	0.000
Availability of unpaid care:				
mother works at home	- 0.329***	0.127	- 0.236*	0.124
partner	- 0.373***	0.056	- 0.399***	0.056
partner not working	- 0.235***	0.067	- 0.160**	0.067
# of older children in household	- 0.340***	0.039	- 0.425***	0.042
# of families in household	- 0.078	0.067	- 0.031	0.066
years at current address	- 0.018***	0.006	- 0.024***	0.006
Availability and/or quality of unpaid care:				
mother's age	0.025	0.035	0.076**	0.036
mother's age^2	- 0.000	0.000	- 0.001*	0.000
mother's education				
left full-time education age 17-age18	0.234***	0.043	0.208***	0.043
left full-time education age19-age21	0.438***	0.055	0.221***	0.058
left full-time education age 21+	0.540***	0.065	0.170**	0.071
ethnic minority	- 0.159**	0.076	- 0.194**	0.081
LA availability of paid care:				
childminder places per 10,000 pop	0.329	0.436	0.373	0.452
(childminder places per 10,000 pop)^2	- 0.175	0.234	- 0.133	0.233
dummy for missing # childminder places	0.114	0.216	0.178	0.230
after school places per 10,000 pop	0.133	0.226	0.189	0.228
(after school places per 10,000 pop)^2	- 0.038	0.159	- 0.110	0.162
dummy for missing # after school places	0.056	0.100	0.095	0.102
holiday club places per 10,000 pop	0.081*	0.046	0.012	0.048
(holiday club places per 10,000 pop)^2	- 0.005	0.005	0.003	0.006
dummy for missing # holiday club places	0.020	0.094	0.064	0.096
Need for care / can afford care:				
# of pre-school children in family	- 0.039	0.043	- 0.015	0.043
# of young school-age children in family	- 0.139***	0.029	- 0.172***	0.031
Can afford paid care:				
ln (mother's weekly earnings)	0.661***	0.043	0.493***	0.044
ln (other weekly family income)	0.165***	0.022	0.145***	0.023
Price:				
child aged 4	0.243***	0.079	0.265***	0.080
child aged 5	0.138**	0.064	0.146**	0.065
child aged 6	- 0.012	0.065	0.011	0.066
child aged 8	- 0.115*	0.064	- 0.099	0.066
child aged 9	- 0.172***	0.066	- 0.160**	0.068
child aged 10	- 0.333***	0.070	- 0.294***	0.072
child aged 11	- 0.720***	0.077	- 0.551***	0.078
LA dummies	included	included	included	included
Constant	- 5.787***	0.724	- 6.540***	0.766
Sample size	12155		12209	
Pseudo R^2	0.255		0.208	

Notes to table 3b: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. 151 (97) observations in 6 (5) local authorities were not used in the term (holiday) probit because no child used paid formal care during the term (holiday) within the local authorities. Figures are for market group 2.

Table 4a: Unit Value Regression: Second Step for Price Estimation: Pre-school Children

Dependent Variable: Ln (Hourly Childcare Expenditure)	**Term time**		**Holidays**	
	Hours Controls	**Hours & Quality Controls**	**Hours Controls**	**Hours & Quality Controls**
ln (childcare hours)	- 0.232***	- 0.261***	- 0.271***	- 0.278***
	(0.021)	(0.022)	(0.023)	(0.024)
Quality of unpaid care:				
mother's age		0.003		0.005
		(0.006)		(0.006)
(mother's age)^2		0.000		0.000
		(0.000)		(0.000)
mother's education				
left FT educ age 17-age18		0.068**		0.068**
		(0.031)		(0.031)
left FT educ age19-age21		0.114***		0.050
		(0.040)		(0.038)
left FT educ age 21+		0.078*		0.058
		(0.046)		(0.039)
ethnic minority		- 0.081*		- 0.057
		(0.044)		(0.045)
Can afford higher quality:				
# of pre-school siblings		- 0.136***		- 0.147***
		(0.027)		(0.029)
# of school siblings		- 0.105***		- 0.160***
		(0.021)		(0.028)
ln (mother's weekly earnings)		0.151***		0.148***
		(0.036)		(0.041)
ln (other weekly family income)		0.032***		0.031**
		(0.012)		(0.012)
Mills ratio from selection regression	- 0.195***	0.078	- 0.229***	0.082
	(0.023)	(0.065)	(0.027)	(0.072)
Constant	- 0.084***	- 0.132*	- 0.094***	- 0.101
	(0.014)	(0.074)	(0.015)	(0.077)
Sample size	1510	1510	1309	1309
Adjusted R^2	0.088	0.112	0.106	0.128

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. Standard errors are shown in parentheses. A term (holiday) regression with the mills ratio as the only regressor generated a coefficient of – 0.112 (- 0.120) and a standard error of 0.023 (0.026) with an adjusted R^2 of 0.015 (0.015). Figures are for market group 2.

Table 4b: Unit Value Regression: Second Step for Price Estimation: School Children

Dependent Variable: Ln (Hourly Childcare Expenditure)	Term time		Holidays	
	Hours Controls	Hours & Quality Controls	Hours Controls	Hours & Quality Controls
ln (childcare hours)	- 0.250***	- 0.247***	- 0.378***	- 0.367***
	(0.021)	(0.021)	(0.035)	(0.034)
Quality of unpaid care:				
mother's age		- 0.003		0.004
		(0.006)		(0.008)
(mother's age)^2		0.000		0.000
		(0.000)		(0.000)
mother's education				
left FT educ age 17-age18		0.061**		0.095**
		(0.032)		(0.039)
left FT educ age19-age21		0.156***		0.142***
		(0.039)		(0.048)
left FT educ age 21+		0.079*		- 0.042
		(0.044)		(0.054)
ethnic minority		- 0.072		- 0.032
		(0.046)		(0.067)
Can afford higher quality:				
# of pre-school siblings		0.028		- 0.083**
		(0.027)		(0.035)
# of school siblings		- 0.127***		- 0.126***
		(0.020)		(0.028)
ln (mother's weekly earnings)		0.196***		0.055
		(0.043)		(0.048)
ln (other weekly family income)		0.019		0.029*
		(0.013)		(0.016)
Mills ratio from selection regression	- 0.143***	0.151**	- 0.213***	- 0.066
	(0.025)	(0.059)	(0.038)	(0.073)
Constant	- 0.080***	- 0.131	- 0.098***	- 0.169
	(0.018)	(0.090)	(0.023)	(0.117)
Sample size	1129	1129	900	900
Adjusted R^2	0.114	0.159	0.125	0.162

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. Standard errors are shown in parentheses. A term (holiday) regression with the mills ratio as the only regressor generated a coefficient of – 0.069 (- 0.117) and a standard error of 0.026 (0.039) with an adjusted R^2 of 0.005 (0.009). Figures are for market group 2.

Table 5: Unit Value Regressions With Childcare Hours by Type of Formal Care

Dependent Variable: Ln (Hourly Childcare Expenditure)	**Pre-School Children**		**School Children**	
	Term time	**Holidays**	**Term time**	**Holidays**
ln (childcare hours) (Omitted category = multiple formal)	- 0.216*** (0.024)	- 0.267*** (0.027)	- 0.217*** (0.045)	- 0.374*** (0.049)
ln (childcare hours) * childminder	- 0.043*** (0.015)	- 0.028* (0.016)	- 0.034 (0.041)	0.011 (0.037)
ln (childcare hours) * day nursery	0.009 (0.015)	0.042*** (0.015)	- 0.063 (0.045)	0.025 (0.041)
ln (childcare hours) * other	- 0.036** (0.018)	- 0.026 (0.018)	- 0.008 (0.042)	- 0.076* (0.039)
Mills ratio from selection regression	- 0.197*** (0.023)	- 0.220*** (0.026)	- 0.137*** (0.025)	- 0.226*** (0.037)
Constant	- 0.085*** (0.014)	- 0.091*** (0.015)	- 0.077*** (0.018)	- 0.105*** (0.023)
Sample size	1510	1309	1129	900
Adjusted R^2	0.114	0.155	0.116	0.153

Notes: Standard errors are shown in parentheses. Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The "other" category is a specific selection chosen by interview respondents and presumably includes crèches, nannies, after-school clubs and holiday clubs. Regressions with the quality control variables produced no significant differences in the coefficients for the childcare hours variables. Figures are for market group 2.

Table 6a: Probit Regressions for Selection Into Paid Formal Care: Coefficients on Different Price Measures: Pre-school Children

Coefficient (Standard Error)	ln Price 1: Raw Means	ln Price 2: Add selection-correction	ln Price 3: Add hours controls	ln Price 4: Add quality controls	Significant differences between prices:
Group 2: LA, age					
During term (n=5184)	- 0.258*** (0.078)	- 0.309*** (0.078)	- 0.453*** (0.079)	- 0.319*** (0.080)	1-3*
During holidays (n=5055)	- 0.266*** (0.080)	- 0.332*** (0.080)	- 0.455*** (0.080)	- 0.308*** (0.082)	1-3*
During term:					
Group 1: LA, age, year (n=3763)	- 0.128*** (0.058)	- 0.127** (0.058)	- 0.226*** (0.059)	- 0.187*** (0.059)	
Group 3: LA, broad age (n=5531)	- 0.151* (0.091)	- 0.250*** (0.092)	- 0.407*** (0.092)	- 0.084 (0.098)	1-3** 3-4**
Group 3: min. cell size (n=3014)	- 0.338* (0.199)	- 0.499*** (0.207)	- 0.678*** (0.196)	- 0.359* (0.212)	
Group 4: LA (n=5604)	-0.054 (0.111)	- 0.265** (0.111)	- 0.500*** (0.111)	0.032 (0.121)	1-3*** 2-4* 3-4***
Group 4: min. cell size (n=4412)	- 0.336* (0.181)	- 0.579*** (0.187)	- 0.803*** (0.176)	- 0.497** (0.198)	1-3*

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The first row of the table presents the coefficient and standard error for the price variable in 8 separate probit regressions for group 2. Each regression also included the variables shown in table 3a with the exception of the child age and local authority dummy variables. The coefficients on the variables not shown were qualitatively unchanged by the replacement of the dummy variables with the price regressor. The second row of the table presents the coefficients for term time using the three alternative groups. The final column presents the results of t-tests for equality of the coefficients using the standard deviation of the coefficient estimate.

Table 6b: Probit Regressions for Selection Into Paid Formal Care: Coefficients on Different Price Measures: School Children

Coefficient (Standard Error)	ln Price 1: Raw Means	ln Price 2: Add selection-correction	ln Price 3: Add hours controls	ln Price 4: Add quality controls	Significant differences between prices:
Group 2: LA, age					
During term (n=9626)	- 0.049 (0.044)	- 0.075* (0.044)	- 0.109** (0.045)	0.006 (0.045)	3-4*
During holidays (n=9070)	0.073* (0.040)	0.043 (0.040)	- 0.021 (0.042)	0.036 (0.042)	
During term:					
Group 1: LA, age, year (n=4635)	- 0.074* (0.045)	- 0.077* (0.045)	- 0.110** (0.047)	- 0.088* (0.047)	
Group 3: LA, broad age (n=11852)	0.028 (0.061)	- 0.083 (0.061)	- 0.153** (0.062)	0.085 (0.062)	1-3** 2-4* 3-4***
Group 3: min. cell size (n=4824)	0.041 (0.187)	- 0.219 (0.185)	- 0.468*** (0.170)	0.129 (0.189)	1-2* 1-3** 3-4**
Group 4: LA (n=12140)	- 0.021 (0.085)	-0.220*** (0.085)	-0.325*** (0.082)	- 0.004 (0.085)	1-3*** 2-4* 3-4***
Group 4: min. cell size (n=8341)	- 0.268* (0.150)	- 0.433*** (0.146)	- 0.572*** (0.137)	- 0.104 (0.155)	3-4**

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The first row of the table presents the coefficient and standard error for the price variable in 8 separate probit regressions for group 2. Each regression also included the variables shown in table 3b with the exception of the child age and local authority dummy variables. The coefficients on the variables not shown were qualitatively unchanged by the replacement of the dummy variables with the price regressor. The second row of the table presents the coefficients for term time using the three alternative groups. The final column presents the results of t-tests for equality of the coefficients using the standard deviation of the coefficient estimate.

Table 7a: Childcare Hours Regressions: Coefficients on Different Price Measures: Pre-school Children

Coefficient (Standard Error)	ln Price 1: Raw Means	ln Price 2: Add selection-correction	ln Price 3: Add hours controls	ln Price 4: Add quality controls	Significant differences between prices:
Group 2: LA, age					
During term (n=1511)	- 0.241*** (0.044)	- 0.293*** (0.050)	- 0.083 (0.055)	- 0.056 (0.051)	1-3** 1-4*** 2-3*** 2-4***
During holidays (n=1310)	- 0.294*** (0.049)	- 0.342*** (0.059)	- 0.090 (0.066)	- 0.050 (0.058)	1-3** 1-4*** 2-3*** 2-4***
During term:					
Group 1: LA, age, year (n=1511)	- 0.254*** (0.030)	- 0.267*** (0.031)	- 0.104*** (0.035)	- 0.084** (0.033)	1-3*** 1-4*** 2-3*** 2-4***
Group 3: LA, broad age (n=1512)	- 0.219*** (0.059)	- 0.266*** (0.063)	- 0.085 (0.067)	- 0.061 (0.064)	1-4* 2-3** 2-4**
Group 3: min. cell size (n=919)	0.005 (0.099)	- 0.060 (0.108)	0.068 (0.107)	0.094 (0.109)	
Group 4: LA (n=1512)	- 0.143** (0.069)	- 0.193*** (0.074)	- 0.067 (0.079)	- 0.034 (0.077)	
Group 4: min. cell size (n=1247)	- 0.067 (0.097)	- 0.128 (0.110)	0.002 (0.112)	-0.004 (0.114)	

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The first row presents the coefficient and standard error for the price variable in 8 separate regressions for group 2. Each regression also included the variables shown in appendix table B3 and the coefficients on the variables were qualitatively unchanged The second row presents the coefficients for term time using the three alternative groups. The final column presents the results of t-tests for equality of the coefficients using the standard deviation of the coefficient estimate.

Table 7b: Childcare Hours Regressions: Coefficients on Different Price Measures: School Children

Coefficient (Standard Error)	ln Price 1: Raw Means	ln Price 2: Add selection-correction	ln Price 3: Add hours controls	ln Price 4: Add quality controls	Significant differences between prices:
Group 2: LA, age					
During term (n=1131)	- 0.339*** (0.051)	- 0.378*** (0.052)	- 0.057 (0.057)	0.005 (0.053)	1-3** 1-4*** 2-3*** 2-4***
During holidays (n=901)	- 0.332*** (0.042)	- 0.338*** (0.042)	- 0.002 (0.047)	- 0.012 (0.047)	1-3** 1-4*** 2-3*** 2-4***
During term:					
Group 1: LA, age, year (n=1129)	- 0.394*** (0.039)	- 0.419*** (0.040)	- 0.111** (0.045)	- 0.095** (0.044)	1-3*** 1-4*** 2-3*** 2-4***
Group 3: LA, broad age (n=1131)	- 0.306*** (0.079)	- 0.406*** (0.081)	- 0.143* (0.086)	0.008 (0.083)	1-4*** 2-3** 2-4***
Group 3: min. cell size (n=507)	- 0.256 (0.192)	- 0.349*** (0.193)	- 0.127 (0.204)	0.028 (0.201)	
Group 4: LA (n=1131)	- 0.237** (0.099)	- 0.381*** (0.104)	- 0.169 (0.112)	- 0.036 (0.101)	2-4**
Group 4: min. cell size (n=833)	- 0.221 (0.156)	- 0.468*** (0.177)	- 0.254 (0.186)	0.038 (0.158)	2-4**

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The first row presents the coefficient and standard error for the price variable in 8 separate regressions for group 2. Each regression also included the variables shown in appendix table B3 and the coefficients on the variables were qualitatively unchanged The second row presents the coefficients for term time using the three alternative groups. The final column presents the results of t-tests for equality of the coefficients using the standard deviation of the coefficient estimate.

Table 8a Quality Regressions For Pre-school Children

Dependent Variable: Quality of Childcare	**Term time**		**Holidays**	
	Quality 1	**Quality 2**	**Quality 1**	**Quality 2**
ln (Price4)	- 0.074*	- 0.080*	- 0.094**	- 0.105**
	(0.039)	(0.042)	(0.044)	(0.047)
Quality of unpaid:				
mother's age	0.022	0.052*	0.033	0.068***
	(0.022)	(0.023)	(0.022)	(0.024)
mother's age^2	- 0.000	- 0.001*	- 0.000	- 0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
mother's education				
left FT educ age 17-age18	0.068**	0.095***	0.064**	0.092***
	(0.030)	(0.032)	(0.030)	(0.032)
left FT educ age19-age21	0.100**	0.149***	0.044	0.085**
	(0.039)	(0.042)	(0.036)	(0.039)
left FT educ age 21+	0.072	0.140***	0.055	0.090**
	(0.044)	(0.048)	(0.036)	(0.038)
ethnic minority	- 0.053	- 0.105**	- 0.026	- 0.075*
	(0.040)	(0.043)	(0.041)	(0.044)
Can afford higher quality:				
# pre-school children	- 0.140***	- 0.116***	- 0.153***	- 0.143***
	(0.027)	(0.029)	(0.029)	(0.032)
# school children	- 0.104***	- 0.101***	- 0.161***	- 0.186***
	(0.020)	(0.022)	(0.028)	(0.030)
ln (mother's weekly earnings)	0.161***	0.045	0.158***	0.081*
	(0.034)	(0.036)	(0.040)	(0.043)
ln (other weekly family income)	0.030***	0.039***	0.027**	0.039***
	(0.011)	(0.012)	(0.012)	(0.013)
Mills ratio from selection regression	0.054	0.140*	0.047	0.197**
	(0.070)	(0.074)	(0.076)	(0.082)
Constant	- 1.292***	-1.423***	- 1.368***	- 1.812***
	(0.483)	(0.516)	(0.519)	(0.559)
Sample size	1510	1510	1309	1309
Adjusted R^2	0.102	0.033	0.110	0.052

Notes: Standard errors are shown in brackets. Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The unit value variation over hours is assumed to reflect a non-linear pricing structure in the quality 1 measure and quality heterogeneity (with a linear price structure) in the quality 2 measure. The figures are for market group 2.

Table 8b Quality Regressions For School Children

Dependent Variable: Quality of Childcare	Term time		Holidays	
	Quality 1	Quality 2	Quality 1	Quality 2
ln (Price4)	- 0.076**	- 0.080**	- 0.067*	- 0.058
	(0.030)	(0.033)	(0.036)	(0.040)
Quality of unpaid:				
mother's age	0.012	0.026	0.009	0.052
	(0.023)	(0.025)	(0.030)	(0.034)
mother's age^2	- 0.000	- 0.000	0.000	- 0.001
	(0.000)	(0.000)	(0.000)	(0.000)
mother's education				
left FT educ age 17-age18	0.055*	0.088**	0.092**	0.097**
	(0.031)	(0.034)	(0.038)	(0.043)
left FT educ age19-age21	0.127***	0.183***	0.123***	0.151***
	(0.038)	(0.042)	(0.046)	(0.053)
left FT educ age 21+	0.063	0.156***	- 0.050	0.027
	(0.043)	(0.047)	(0.053)	(0.060)
ethnic minority	- 0.062	- 0.099**	- 0.026	- 0.047
	(0.040)	(0.045)	(0.058)	(0.065)
Can afford higher quality:				
# pre-school children	0.018	0.042	- 0.087***	- 0.029
	(0.026)	(0.029)	(0.033)	(0.037)
# school children	- 0.130***	- 0.128***	- 0.130***	- 0.129***
	(0.020)	(0.022)	(0.028)	(0.032)
ln (mother's weekly earnings)	0.184***	0.152***	0.057	0.010
	(0.040)	(0.044)	(0.044)	(0.050)
ln (other weekly family income)	0.014	0.034***	0.025	0.047***
	(0.012)	(0.013)	(0.015)	(0.017)
Mills ratio from selection regression	0.086	0.247***	- 0.105	0.108
	(0.055)	(0.061)	(0.065)	(0.074)
Constant	- 1.213***	- 1.737***	- 0.391	- 1.470**
	(0.463)	(0.514)	(0.608)	(0.690)
Sample size	1129	1129	900	900
Adjusted R^2	0.092	0.063	0.087	0.052

Notes: Standard errors are shown in brackets. Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The unit value variation over hours is assumed to reflect a non-linear pricing structure in the quality 1 measure and quality heterogeneity (with a linear price structure) in the quality 2 measure. The figures are for market group 2.

Appendix A

The solution to the model described in section 2 is presented in the first subsection under the heading of Model 1. Three slightly modified versions of the model are then explored in the following three subsections.

Model 1: The Complete Model Without the Constraint Binding

Consider first the solution when the time constraint is not binding. To repeat from the main text, the problem for the family is to choose the optimal hours of work for the mother, hours of formal childcare and the quality of formal care in order to maximise the utility from consumption, leisure and childcare quality:

$$\max_{H,F,q} U = U[C, L, Q] = U[Y + wH - \Pi.r[q, F].nF, T - H, Q[q_m, q, F]]$$

$$\text{subject to} \quad \overline{F} \geq F \geq \left(H - \frac{\overline{I}}{n} \right)$$

The utility maximisation problem is solved subject to the exogenous parameters Y, w, Π, n, q_M, $\overline{F}$ and $\overline{I}$. The utility function is assumed to be additively separable and concave in each of its arguments. The three first order conditions require that the marginal derivatives of utility with respect to H, F and q are set equal to zero:

(1) $w.U_C = U_L$

(2) $n\Pi.(r + F.r_F).U_C = Q_F.U_Q$

(3) $n\Pi F.r_q.U_C = Q_q.U_Q$

where the arguments of the functions have been suppressed and G_x denotes the first derivative of the function G with respect to the element x. Condition (1) is the usual labour supply condition in the absence of childcare considerations, with the amendment that the marginal utility of income will be higher if paid childcare is used, raising the optimal level of work hours. The second condition equates the marginal cost in terms of foregone consumption of an additional unit of formal care with the marginal benefit to childcare quality. The third condition equates the marginal cost of additional quality of childcare in terms of foregone consumption with the marginal benefit in childcare quality and is only relevant if formal care is used ($F > 0$).

The comparative statics of the model can be derived using the Hessian matrix of second order derivatives. Using the notation f_{nx} to denote the partial derivative of the nth first order condition with respect to x and the notation $G_{x_1x_2}$ to denote the second derivative of the function G with respect to x_1 and x_2, the comparative statics with respect to the childcare price Π can be written as the following system of simultaneous equations:

$$\begin{pmatrix} f_{1H} & f_{1F} & f_{1q} \\ f_{2H} & f_{2F} & f_{2q} \\ f_{3H} & f_{3F} & f_{3q} \end{pmatrix} \begin{pmatrix} dH \\ dF \\ dq \end{pmatrix} = \begin{pmatrix} f_{1p} \\ f_{2p} \\ f_{3p} \end{pmatrix} d\Pi$$

where the signs of the Hessian matrix are given by:

$$f_{1H} = w^2.U_{CC} + U_{LL} < 0$$

$$f_{2F} = -n\Pi(2.r_F + F.r_{FF}).U_C + n^2\Pi^2(r + F.r_F).U_{CC} + \left(Q_{FF}.U_Q + Q_F.U_{QQ}\right)$$

< 0 under the second order conditions for a maximum

$$f_{3q} = -n\Pi F.r_{qq}.U_C + \left(n\Pi F.r_q\right)^2.U_{CC} + \left(Q_{qq}.U_Q + {Q_q}^2.U_{QQ}\right)$$

< 0 under the second order conditions for a maximum

$$f_{1F} = f_{2H} = -wn\Pi(r + F.r_F).U_{CC} > 0$$

$$f_{1q} = f_{3H} = -wn\Pi F.r_q.U_{CC} > 0$$

$$f_{2q} = f_{3F} = -n\Pi\left(r_q + F.r_{Fq}\right).U_C + n^2\Pi^2 F(r + F.r_F).r_q.U_{CC} + \left(Q_{Fq}.U_Q + Q_F.Q_q.U_{QQ}\right)$$

< 0 if $r_{Fq} \geq 0$, $Q_{Fq} \leq 0$, $Q_F \geq 0$ (sufficient, but not necessary conditions)

and the partial derivatives with respect to the price of childcare are given by:

$$f_{1p} = -wnFr.U_{CC} > 0$$

$$f_{2p} = -n.(r + F.r_F).U_C + n^2\Pi rF(r + F.r_F).Ucc < 0$$

$$f_{3p} = -nF.r_q.U_C + n^2\Pi F^2 r.r_q.U_{CC} < 0$$

The second order conditions for a maximum require that the Hessian matrix is negative semidefinitie. Using Cramer's rule, the total derivative for outcome

$x \in (H, F, q)$ can be calculated using $\frac{dx}{d\Pi} = \frac{\det \bar{\Delta}}{\det \Delta}$ where $(\det \Delta)$ denotes the determinant of the Hessian matrix and $(\det \bar{\Delta})$ denotes the determinant of the Hessian matrix with the column of derivative with respect to x replaced by the column of derivatives with respect to Π. Although the second order conditions for a maximum require $(\det \Delta)$ to be negative, none of the signs of $(\det \bar{\Delta})$ are determined. This is true not just for the childcare price, but for all of the exogenous parameters.

Model 2: The Complete Model With the Constraint Binding

If the constraint on the minimum level of formal hours of childcare binds, the solution corresponds approximately to the assumption that the hours of non-maternal childcare must equate with hours of work and corresponds exactly to the assumption if no informal care is available $\left(\bar{I} = 0\right)$. The optimal choices combine the first order conditions (1) and (2) to generate:

$$(1+2) \quad w.U_C - n\Pi.\left(r + \left(H - \frac{\bar{I}}{n}\right).r_F\right).U_C = U_L - Q_F.U_Q$$

$$(3) \qquad n\Pi\left(H - \frac{\bar{I}}{n}\right).r_q.U_c = Q_q.U_q$$

In this situation, hours of work are required not only to satisfy the traditional balance of the marginal utility of income and the marginal utility of leisure, but also the cost and benefit of hours of formal childcare. The left-hand side of equation (1+2) can also be rewritten as $\left(w - \Pi.\left(r + H.r_F\right)\right).U_C$ showing that under these conditions, the wage is effectively considered as being net of childcare costs. However, the signs of the comparative statics of the model remain undetermined when the constraint binds.

Model 3: The Complete Model With Exogneous Hours of Work

Consider the case where we abstract from the labour supply of the mother and assume that H is determined exogenously, but the constraint on F is not binding. In this situation, the family chooses hours and quality of formal care subject to the exogenous parameters, including the mother's hours of work. The optimal solution is described by the first order conditions (2) and (3), where H enters through the marginal utility of income. However, the signs of the effects of the exogenous parameters on the childcare choices are still not determined a priori.

Model 4: The Model Without Childcare Quality

As a point of comparison, the model without childcare quality can be derived. In this case, the time constraint binds under the optimal choices because formal care is not a "good" and the only reason to use it is to facilitate work. For notational simplicity, it is assumed that there is no informal care available and that the hourly price of formal care does not change with the hours of care so that the Z function is redundant. The utility maximisation problem is given by:

$$\max_{H} U = U\left[C, L\right] = U\left[Y + wH - \Pi nH, T - H\right]$$

Hence, optimal behaviour is identical to the standard labour supply model with the wage treated as net of childcare costs. The first order condition is simply:

(1) $\quad \left(w - \Pi n\right).U_C = U_L$

and the comparative statics are given by:

$$\frac{dH}{dY} = \frac{-\left(w - \Pi n\right)^2.U_{CC}}{\left(w - \Pi n\right)^2.U_{CC} + U_{LL}} < 0$$

$$\frac{dH}{dw} = -\left(\frac{dH}{d\Pi}\right) = -\left(\frac{dH}{dn}\right) = \frac{U_C + \left(w - \Pi n\right).H.U_{CC}}{\left(w - \Pi n\right)^2.U_{CC} + U_{LL}}$$

Hence, the response of hours of work to a rise in other family income is unambiguously negative, while the response to the other exogenous parameters depends upon the relative magnitudes of the conflicting substitution and income effects.

Appendix B

Table B1: Sample Statistics for Children with Working Mothers

	Pre-school Children	School Children
	mean (standard deviation)	mean (standard deviation)
Number of children in family:		
pre-school (aged 0-4)	1.30 (0.49)	0.22 (0.45)
school (aged 4-11)	0.48 (0.68)	1.68 (0.70)
older (aged 12-18)	0.07 (0.31)	0.33 (0.60)
% of mothers with partners	90.0	84.3
% of mothers with non-working partners	8.2	11.1
% with additional benefit unit in household	5.1	6.6
% non-white	6.8	6.3
% of mothers work at home	3.7	3.4
Years at current address	4.0 (3.0)	5.3 (3.6)
Mother's age	31.2 (5.0)	35.8 (5.2)
Age mother left education:		
% at 16 or less	47.2	55.2
% at 17-18	31.0	27.6
% at 19-21	12.1	10.8
% at greater than 21	9.7	6.4
Mother's weekly work hours	24.2 (12.0)	24.1 (12.1)
Mother's weekly earnings	147.95 (124.12)	130.79 (114.55)
Other weekly income	290.21 (314.48)	286.43 (225.02)
Paid formal care:		
% using during term-time	33.7	11.5
% using during holidays	29.2	9.6
weekly hours during term-time	29.7 (13.6)	11.6 (9.3)
weekly hours during holidays	30.7 (13.6)	30.3 (14.1)
hourly expenditure during term-time	2.20 (1.35)	2.26 (1.55)
hourly expenditure during holidays	2.18 (1.34)	1.70 (1.30)
Local Authority variables: Number of places per 10,000 relevant population:		
day nurseries	559.6 (327.0)	-
playgroups	1093.4 (709.2)	-
childminders	689.4 (320.8)	686.1 (316.6)
after school clubs	-	248.4 (252.6)
holiday clubs	-	803.3 (1074.6)
% missing number of day nurseries places	11.8	-
% missing number of playgroup places	14.4	-
% missing number of childminder places	6.0	5.5
% missing number of after school club places	-	15.3
% missing number of holiday club places	-	17.8
Total number of mothers in sample	4798	8649
Total number of children:		
in sample	5604	12306
with term time childcare expenditure	1510	1129
with holiday childcare expenditure	1309	900

Notes: All monetary values are indexed to January 1999. Other weekly income includes all family income except mother's earnings

Table B2: Sample Sizes Across Different Market Definitions

Market	Percentage of sample in participation probit	Percentage of sample with price prediction	Number of markets	Mean number of observations in each market (cell size)
Pre-school Children				
Group 2: LA, age				
During term	95.3	92.5	420	3.6
With minimum cell size 10	23.8	16.0	26	12.6
During holidays	93.3	90.2	398	3.3
With minimum cell size 10	18.8	10.8	17	12.5
During term:				
Group 1: LA, age, year	75.5	67.2	973	1.6
With minimum cell size 10	0.0	0.0	0	0.0
Group 3: LA, broad age	99.0	98.7	204	7.4
With minimum cell size 10	68.5	53.8	54	17.0
Group 4: LA	100.0	100.0	107	14.1
With minimum cell size 10	83.2	78.7	55	22.7
School Children				
Group 2: LA, age				
During term	82.3	78.2	522	2.2
With minimum cell size 10	0.6	0.0	0	0.0
During holidays	80.0	73.7	468	1.9
With minimum cell size 10	1.0	0.3	1	10.0
During term:				
Group 1: LA, age, year	43.9	37.7	886	1.3
With minimum cell size 10	0.0	0.0	0	0.0
Group 3: LA, broad age	97.7	96.3	191	5.9
With minimum cell size 10	49.4	39.2	36	14.1
Group 4: LA	98.8	98.7	101	11.1
With minimum cell size 10	79.6	67.8	45	18.5

Notes: LA denotes local authority. Broad age combines ages 1 to 3 and 4 to 5 for pre-school children and ages 4 to 6 and 7 to 11 for school children. The rows also show the figures for each group "with minimum cell size 10", requiring each cell to have at least 10 hourly expenditure observations for the unit value regression. Hence, the column showing the percentage of sample in the participation probit reports the proportion of households in a cell with at least one household (10 households in the with minimum cell size) using paid formal childcare. Similarly, the column showing the percentage of sample with a price prediction reports the proportion in a cell with at least one (at least 10) observation with an hourly childcare expenditure.

Table B3: Hours Regressions Using Selection-Corrected Price (Price 2)

Dependent variable:	**Pre-school Children**		**School Children**	
Ln (hours of childcare)	**Term**	**Holiday**	**Term**	**Holiday**
Ln (price2)	- 0.293***	- 0.342***	- 0.378***	- 0.338***
	(0.050)	(0.059)	(0.052)	(0.043)
Need for care:				
mother's work hours	0.051***	0.052***	0.058***	0.046***
	(0.005)	(0.006)	(0.009)	(0.010)
(mother's work hours)^2	- 0.000***	- 0.000***	- 0.001***	- 0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Availability of unpaid care:				
mother works at home	- 0.168*	- 0.110	- 0.026**	- 0.217
	(0.095)	(0.117)	(0.170)	(0.149)
partner	- 0.154***	- 0.137**	- 0.270***	- 0.107
	(0.053)	(0.060)	(0.083)	(0.081)
partner not working	- 0.126**	- 0.104*	- 0.224***	- 0.234***
	(0.054)	(0.057)	(0.086)	(0.081)
# of older children in household	- 0.086**	- 0.073	- 0.279***	- 0.266***
	(0.043)	(0.056)	(0.086)	(0.095)
# of families in household	0.081	0.143**	0.180**	0.017
	(0.055)	(0.058)	(0.072)	(0.064)
years at current address	- 0.008	- 0.004	- 0.006	- 0.006
	(0.005)	(0.006)	(0.007)	(0.008)
Availability and/or quality of unpaid care:				
mother's age	0.016	0.026	- 0.008	- 0.050
	(0.029)	(0.033)	(0.040)	(0.039)
mother's age^2	- 0.000	- 0.000	0.000	0.001
	(0.000)	(0.000)	(0.001)	(0.001)
mother's education				
left full-time education age 17-age18	0.052	0.047	0.125**	0.141**
	(0.041)	(0.043)	(0.066)	(0.057)
left full-time education age19-age21	0.105*	0.088	0.231**	0.145**
	(0.059)	(0.055)	(0.095)	(0.071)
left full-time education age 21+	0.101	0.073	0.200*	0.062
	(0.069)	(0.050)	(0.114)	(0.083)
ethnic minority	0.010	0.011	0.057	- 0.024
	(0.053)	(0.054)	(0.070)	(0.073)
Need for care / can afford care:				
# of pre-school children in family	- 0.146***	- 0.116***	- 0.056	- 0.121***
	(0.036)	(0.044)	(0.046)	(0.043)
# of young school-age children in family	- 0.088***	- 0.079*	- 0.109***	- 0.129***
	(0.028)	(0.046)	(0.041)	(0.047)
Can afford paid care:				
ln (mother's weekly earnings)	0.352***	0.289***	0.384***	0.259**
	(0.053)	(0.068)	(0.119)	(0.097)
ln (other weekly family income)	0.046***	0.046**	0.055*	0.012
	(0.017)	(0.020)	(0.034)	(0.032)
Mills ratio from selection regression	0.203*	0.115	- 0.292	0.108
	(0.121)	(0.155)	(0.210)	(0.207)
Constant	0.058	0.222	- 1.016	2.120*
	(0.757)	(0.958)	(1.179)	(1.277)
Sample size	1511	1310	1131	901
Adjusted R^2	0.443	0.398	0.290	0.304

Table B4: Quality Regressions: Coefficients on the Final Price Measure (Price4)

Dependent variable: Quality of childcare	Quality 1		Quality 2	
	Coefficient	Standard Error	Coefficient	Standard Error
Pre-school Children				
Group 2: LA, age				
During term (n=1510)	- 0.074*	0.039	- 0.080*	0.042
During holidays (n=1309)	- 0.094**	0.044	- 0.105**	0.047
During term:				
Group 1: LA, age, year (n=1510)	- 0.055***	0.018	- 0.045**	0.020
Group 3: LA, broad age (n=1510)	- 0.066	0.056	- 0.048	0.059
Group 3: minimum cell size (n=919)	0.011	0.107	- 0.038	0.112
Group 4: LA (n=1510)	- 0.031	0.069	- 0.008	0.073
Group 4: minimum cell size (n=1247)	- 0.024	0.103	- 0.048	0.109
School Children				
Group 2: LA, age				
During term (n=1129)	- 0.076**	0.030	- 0.080**	0.033
During holidays (n=900)	- 0.067*	0.036	- 0.058	0.040
During term:				
Group 1: LA, age, year (n=1129)	- 0.028*	0.015	- 0.024	0.018
Group 3: LA, broad age (n=1129)	- 0.115**	0.057	- 0.100	0.061
Group 3: minimum cell size (n=507)	- 0.122	0.139	- 0.109	0.150
Group 4: LA (n=1129)	- 0.134*	0.074	- 0.125*	0.079
Group 4: minimum cell size (n=832)	- 0.092	0.120	- 0.122	0.127

Notes: Stars indicate significantly different from zero at 1% (***), 5 % (**) and 10% (*) level. The first and third rows of the table each present the coefficient and standard error for the price variable in 4 separate regressions for group 2. Each regression also included the variables shown in tables 9a and 9b and the coefficients on the variables were qualitatively unchanged. The other two rows of the table present the coefficients for term time using the three alternative groups. The unit value variation over hours is assumed to reflect a non-linear pricing structure in the quality 1 measure and quality heterogeneity (with a linear price structure) in the quality 2 measure.