market. T is the total number of hours available; L, the time dedicated to leisure; and R, the time dedicated to unpaid work in the household and in the community. Solving for the first order condition, we derive the following function:

$$H = (w, A, X) \tag{4}$$

which can be estimated in a semi-logarithmic form

$$H = \pi + \alpha Lnw + \beta A + \gamma X + \varepsilon \tag{5}$$

and a wage determination function:

$$w = \delta + \varphi X + \upsilon \tag{6}$$

A problem occurs when we attempt to estimate these functions. The sample is truncated. We observe only those individuals who are currently working and receiving a wage. The number of hours worked and the wages are zero for those who are unemployed or outside the labor market. But their labor would command a return should they be in the labor market. A wage determination or labor supply function will suffer from selection bias if it is estimated by OLS. Applying the procedure developed by Heckman, we can correct the estimates using the inverse Mills ratio,[1] as a variable in the labor supply equation. The inverse Mills ratio is calculated as a function of the probability that an individual is in the labor market using the entire sample. The excluded variables in the labor supply equation serve as instruments in the full-sample estimates as part of a two-stage least-squares estimation procedure:

$$w = f(X, Inv) \tag{7}$$

where X represents personal characteristics such as age, education level, gender, etc., and Inv is the inverse Mills ratio. This allows us to estimate the opportunity cost of unpaid work in the household. We assume that in equilibrium, the marginal value of an hour of reproductive work is equivalent to the marginal value of paid work.

NOTE

[1] The inverse Mills ratio corrects the β coefficients for omitted variable bias (Heckman 1976).

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VALUING PARENTAL CHILDCARE IN THE UNITED KINGDOM

Killian Mullan

ABSTRACT

A recognized shortcoming of the present system of national accounting (the United Nations System of National Accounts) is the omission of nonmarket production from national accounts. Arguably, some of the most important nonmarket production carried out within the home relates to the care of children. This study estimates the monetary value of the childcare provided by parents to children ages 0–13 years in the United Kingdom, exploiting a unique data source that contains information on the amount of time spent on childcare from the perspectives of both parents and children. Using these data, the time input into childcare by parents and the time output of care are both measured and valued. Results at the micro level focus on variation of the imputed value of inputs and outputs of childcare by gender, household structure, and household composition. At the macro level, estimates of the imputed value of childcare are compared to the UK's gross domestic product (GDP).

KEYWORDS

Childcare, national income accounting, time use, unpaid household work

JEL Codes: D13, E01, J13

INTRODUCTION

If parents choose not to provide childcare but rather purchase those services in the market, there will be an increase in the national product. When this occurs, the infamous jibe about the housekeeper who marries her employer and thereby reduces national product is played out in reverse.[1] Increased female labor force participation can be linked with increased demand for and improved access to childcare services in Organisation for Co-operation and Economic Development (OECD) countries (Florence Jaumotte 2003). In the UK, for example, government expenditure to subsidize the increasing consumption of childcare services is an implicit recognition that childcare provided by parents is a public good (Nancy Folbre 1994).[2] The increasing portion of childcare that then becomes "visible" because it is reflected in the national product (via private or public expenditure) will be much smaller than the total amount

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of care provided by parents. However, it is, to say the least, inconsistent to regard the care produced in the market as valuable, while devaluing the vast majority of care provided by parents, simply because the latter is produced within the home. This inconsistency has been repeatedly highlighted (Simon Kuznets 1944, cited in Oli Hawrylyshyn 1976; Jean Colin Clark 1958; William D. Nordhaus and James Tobin 1973; Hans J. Alder and Oli Hawrylyshyn 1978; Bonnie G. Birnbaum and Marianne A. Ferber 1980; and Robert Eisner 1988.).[3]

This study focuses on childcare by parents of children ages 0–13 years in the UK, including biological or step parents co-resident with the child. It is certainly not hyperbole to argue that raising children is one of the most important human endeavors, ensuring as it does the continuation of society itself. The chief input into the production of childcare is parental time and, in particular, mothers' time. The output of childcare is the care that each child receives as measured by time spent with a parent or, where applicable, both parents together. This measure of care from the perspective of each child is the central plank of the output approach. To date, there has never been a valuation of any element of household production where both the time inputs and time outputs of childcare have been measured and valued independently. Although focused on the UK, this study tackles broader issues in relation to the measurement and valuation of childcare, which apply to developing and OECD countries alike. The study contributes to ongoing international efforts to value household production by carrying out a thorough valuation of both inputs and outputs of one of the most important elements in the household production set. Because time is the measure of both the input and the output, time-use data plays a pivotal role in enabling this valuation.

TIME-USE DATA

Jonathan Gershuny (1979) writes that time-use diaries present the best opportunity to measure the activities associated with household production. These data have been central in bringing to the fore the large amount of time women spend in household production activities (Joann Vanek 1974). Time-use data have invariably been used to quantify the time inputs to household production (Sandra Short 2000), although they are not limited to the measurement of those inputs. This study uses the United Kingdom Time Use Survey 2000 (hereafter the UKTUS) to measure the care time input and the care time output of childcare. Within households selected to participate in the UKTUS, all individuals ages 8 years and older completed a time diary for one weekday and one weekend day. In each diary, respondents described the sequence of main or primary activities they engaged in throughout the day. Respondents also indicated whom they were with (known as co-presence) and where they were while engaged in

these activities. This sort of information, recorded in parallel with details about all activities carried out during the day, is often referred to as contextual information. As shown below, it plays a pivotal role in the measurement of childcare.

VALUING HOUSHOLD PRODUCTION: INPUTS VERSUS OUTPUTS

Market-based national accounts include an income account that sums all incomes generated from production and an expenditure account that sums all expenditure on goods and services produced.[4] Methods of valuing household production have sought to impute a shadow wage for the work done (an extension of the income account) or to impute prices for the outputs produced (an extension of the expenditure account). These approaches shall be referred to as the "input" approach and the "output" approach, respectively. Historically, valuations using an input approach are more common (see Hawrylyshyn [1976]; Luisella Goldschmidt-Clermont [1983]; and International Research and Training Institute for the Advancement of Women [INSTRAW 1995] for extensive reviews of input-based approaches). However, many researchers regard the output method as superior (Goldschmidt-Clermont 1983, Ronald Schettkat 1985; John Fitzgerald and John Wicks 1990; Luisella Goldschmidt-Clermont 1993b). This viewpoint is very much in line with guidelines for market-based national accounts, which state that market prices for goods and services are the "basic reference for valuation in the system" (United Nations 1993: 2.68). The output method is deemed better because it incorporates the costs of all inputs in the value of the output. Also, variation in the value of the labor input over time may be attributed to changes in productivity within the market and not the home, leading to potentially misleading conclusions about changes over time (Luisella Goldschmidt-Clermont 1993a). Euston Quah (1993), on the other hand, points out that it is not always easy to identify and measure outputs from household production, whereas time spent doing household work, in contrast, is an unambiguous measure. Proponents of output-based approaches are aware of this. Fitzgerald and Wicks (1990), in a US study, point out that successfully identifying distinct output is crucial to the success of the method, and they demonstrate that it is feasible. While early examples of output-based approaches include Margaret Mietus Sanik and Kathyrn Stafford (1983) and Gordon Bivens and Carole Volker (1986), both in the US, more recent examples are rare, leading to the pragmatic view that a good input-based valuation is preferable to none at all (Katharine G. Abraham and Christopher Mackie 2005).

There has been a movement toward the view that both the inputs to and outputs from household production should be quantified and valued

independently (Abraham and Mackie 2005: Recommendation 1.3). Recording inputs and outputs in a double-entry bookkeeping system reflects the underlying system of production (Paul Studenski 1958). The market-based accounts balance in aggregate because each individual firm operates in such a way that its revenues from outputs cover the costs arising from the use of inputs. If each firm in the market balances its accounts, then the aggregate across the whole market economy will reflect this. Firms may run at a loss periodically, but this cannot be sustained over the long run and inefficient firms will eventually be driven from the market (Abraham and Mackie 2005). Competitive market pressures do not exist for households and, therefore, "the cost of time devoted to home production could exceed or fall short of its productive [output] value" (Abraham and Mackie 2005: 24). Douglas Dalenberg, John Fitzgerald, and John Wicks (2004), in their valuation of home-produced childcare in the US, find that the value of care derived using the output method is less than the value if measured using an input method. They argue that economies of scale in daycare facilities are the main reason for this difference, as they lead to lower prices being assigned in the output method compared to the shadow wages assigned as part of an input method.

At the micro (household) level, the input and output approaches are likely to produce varying results, especially in a labor-intensive activity such as childcare, and these will be sustained over considerable periods of time. The structure and composition of households, in particular, has an important bearing on outcomes generated by each method. An input method is likely to result in a higher imputed value of childcare in two-parent households relative to lone-mother households, simply because the input value sums the time both parents are caring for children and does not account for how many children are being cared for. Furthermore, differences in the number of children could compound the differences between household types because, as researchers in Australia have found, the added parental time input produced by caring for a second or third child is much lower than the initial outlay of time caring for a single child (Lyn Craig and Michael Bittman 2008). Using an input method could, therefore, produce some highly misleading outcomes. For example, an input method could show that a lone mother with two children produces less childcare than a two-parent household with one child. An output method, which focuses on the children and not the parents, would result in a more accurate valuation of the care produced in lone-mother households relative to that of two-parent households. In addition, because an output approach is child-centric, it differentiates between care provided by both parents together and care provided by each parent individually. This is important from a gender perspective, as Australian research has shown that much more of care provided by mothers in two-parent households is done

individually and away from the father (Lyn Craig 2007). To elaborate on these issues, I now turn to the methods of measuring and valuing the inputs and outputs of childcare.

VALUING CHILDCARE: INPUTS AND OUTPUTS

For both the input and output methods, the value of childcare is computed as $V = Q^*P$, where Q is the quantity of input or output and P is the shadow wage or price, respectively. The challenges lie with the conceptualization and measurement of Q and the choice of P. The following describes the conceptualization and measurement of the input quantity and discusses the strategy for assigning shadow wages. It also details the conceptualization and measurement of the quantity of the output of childcare and the pricing strategy for the output method.

INPUT METHOD

The time input to childcare

The question of what time is considered work for national accounting purposes has been answered using the "third person criterion." This criterion states that if time is spent doing something that another person could be hired to do, then for the purposes of valuation it is productive work (Margaret G. Reid [1934], cited in INSTRAW [1996: 11]). In practical applications, the third-person criterion has been applied to household production activities carried out as the main or primary activity. Often, valuations of time spent caring for children use a single aggregate measure of primary activity childcare (Johanna Varjonen and Kristiina Aalto 2006; Alfonso Sousa-Poza, Hans Schmid, and Rolf Widmer 2001). However, childcare is an extremely heterogeneous activity, and researchers are beginning to move toward more refined care typologies (Michael Bittman, Lyn Craig, and Nancy Folbre 2004). The UKTUS contains eight separate distinct codes for "childcare of own household members," and groups these codes into three general categories of care:

(1) Physical care includes unspecified childcare (3800); unspecified physical care and supervision (3810); feeding the child (3811); other specified physical care and supervision (3819); and other specified childcare (3890).
(2) Talk-based care includes teaching the child (3820); and reading, playing, and talking with the child (3830).
(3) Accompanying a child is its own category, with the code 3840.

The first category of care is physical care and includes a small amount of "unspecified" and "other" childcare. It also includes an unknown quantity of time when a parent will have recorded supervision as the main activity. It is unknown because the UKTUS does not code supervision as a distinct activity (see above). The second category of care is referred to as talk-based care. It consists of reading, playing, or talking to a child and teaching a child. The third and final category of care is time spent accompanying a child.

Grouping childcare activities in this way is an improvement over a single childcare aggregate; however, researchers have sharply criticized the practice of childcare recorded as a primary activity by pointing to the large quantity of supervisory care that is not recorded as a primary activity (Duncan Ironmonger 2004; Michelle J. Budig and Nancy Folbre 2004; Cara B. Fedick, Shelly Pacholok, and Anne H. Gauthier 2005; Craig 2007; Nancy Folbre and Jayoung Yoon 2007). Much of the care provided by the market is supervisory in nature, and so this care, as the specific care activities highlighted above, easily passes the third person criterion and, on this basis, should be included in a measure of the time input to the production of childcare. The measurement and valuation of supervisory care is integral to a comprehensive estimate of all childcare produced by households.

A good measure of supervisory childcare must accommodate the time parents and children are not in the same room but are in the same location. Furthermore, measures of supervisory care are better if not connected to specific activities. An example of a measure satisfying both these requirements is available in the American Time Use Survey (ATUS), which asked respondents if a child is "in your care" (Folbre and Yoon 2007). The survey asked the question regardless of the respondents' primary activity and designed the phrasing of the question to cover situations when a parent and child are not in the same room (Lisa K. Schwartz 2001). Co-presence data in UKTUS share these two key characteristics of the "in your care" measure, which makes it an appropriate measure of supervisory care. The similarity of the co-presence data and the "in your care" measure has been noted by others (Folbre and Yoon 2007). Researchers have previously used co-presence in extended measures of childcare (Lyn Craig 2006; Cristina Fernandez and Almudena Sevilla Sanz 2006), and time with children has been recognized as a measure of parental childcare (Mary Dorinda Allard, Suzanne Bianchi, Jay Stewart, and Vanessa R. Wight 2007). W. Keith Bryant and Cathleen D. Zick state that the time parents are with their children is "inherently different" in nature than time without them (1996: 235).

Excluding supervisory care will result in an underestimate of the total value of childcare produced by parents, although including such care raises the issue of joint production. Supervisory care takes place when a caretaker is doing some other primary activity, including other household production activities. For example, at certain periods, a mother can provide care for

her children (Output 1) and cook dinner (Output 2). Indeed, the presence of children has been shown to increase the amount of time spent doing other household production activities (Craig and Bittman 2008). Technically, this issue relates to economies of scope. These arise in the market when firms, seeking to minimize costs, exploit a "quasi-public shareable input" to produce two or more goods simultaneously (John C. Panzar and Robert D. Willig 1981: 268). If the cost of producing the two goods simultaneously is cheaper than producing those goods separately, economies of scope are achieved (Panzar and Willig 1981; William W. Sharkey 1982). Within the household, economies of scope can arise when a parent is doing some other household production activity while providing supervisory childcare. They can also arise when the parent records doing a specific childcare activity as well as another household production activity.

This latter scenario applies to all childcare recorded as a secondary activity but, more strictly, it also applies to a portion of primary activity childcare carried out when doing some other secondary activity. Secondary activity care is often referred to as simultaneous by definition. However, primary activity care combined with another activity is also simultaneous care. The difference is that secondary care will always be combined with another activity, whereas most primary activity care is not. The natural opposite of simultaneous or combined care is care done with no other activity – undivided care. For the purposes of this valuation, this study proposes to reclassify all childcare activities depending upon whether they were carried out as the sole activity or combined with some other activity (see also Charlene M. Kalenkoski and Gigi Foster [2008]). The other activities might be domestic work, leisure activities, personal care, or traveling. Other time spent with a child but not doing a specific childcare activity, which is a measure of supervisory care, constitutes a final type of care. There are thus six distinct care jobs: (1) Undivided physical care; (2) Undivided talk-based care; (3) Accompanying a child; (4) Combined physical care; (5) Combined talk-based care; (6) Supervisory care (time with a child but not doing a childcare activity).[5]

It is now possible to clearly distinguish between childcare that is combined with other activities and that which is not. This study provides a range of estimates varying in the extent to which the care time is shared with other activities. The first and most restricted estimate includes care jobs 1, 2, and 3. The second estimate adds care jobs 4 and 5. Finally, the least restrictive estimate combines all care jobs. Obviously, the estimate of the value of childcare will increase moving from the most to least restrictive. However, moving toward the least restrictive estimate, the valuation becomes more partial because the production of other outputs is not explicitly considered. In other words, the shadow wage assigned to the time input in these instances focus only on the childcare dimensions of that

time. A valuation of all household production will have to address the question of how to assign a shadow wage to time when more than one output is being produced simultaneously. Below, this study focuses on how different aspects of childcare can be assigned different shadow wages.

Assigning shadow wages

There are two main approaches to assigning shadow wages for time spent in household production. The first uses the wage a person would earn in the market and is known as the opportunity cost method. This approach is based on an extension of the proposition in economic theory that, at the margin, the wage rate is the value of leisure. The extension states that the wage rate not only reflects the opportunity cost of leisure time, but also the opportunity cost of time spent in home production.[6] The market wage, however, may not be an accurate reflection of the actual opportunity cost of time spent in household production. In particular, opportunity cost may not be uniform across the entire day or across days of the week (Abraham and Mackie 2005). For example, the opportunity cost of an hour on a Monday morning may not be the same as the opportunity cost of an hour on a Saturday evening. In addition, it has been argued that any enjoyment or process benefits that accrue from time spent engaging in productive activity within the home should be deducted from any estimate of opportunity cost (Thomas F. Juster 1990; Abraham and Mackie 2005).[7] From a strictly economic point of view, if you are enjoying yourself then the time is more akin to leisure than work regardless of whether it satisfies the third-person criterion. Process benefits, however, accrue in market work also but are completely ignored in estimates of the value of market work. This situation notwithstanding, it may be reasonable to discount process benefits when estimating the opportunity cost of the time a person spends working in the garden on a sunny Saturday afternoon, but it is a highly dubious proposition with respect to time spent caring for children. Indeed, it can be argued that these process benefits are intimately intertwined with the motivation to provide care, which in turn is difficult to separate from the action of care (Nancy Folbre and Julie A. Nelson 2000).

The second approach is the replacement cost approach, which this study uses. This approach follows directly from the third person criterion. Recall that the third-person criterion asks if someone else could do the activity. The replacement cost approach asks how much this other person could expect to be paid for providing care. As with the opportunity cost approach, this approach, though not as problematic empirically, also runs into difficulty when applied to childcare. Susan Himmelweit (1995) argues that one of the characteristics of "work" is that it is possible to separate the work from the worker. However, she also argues that this assumption is highly problematic when thinking about caring work, as it is difficult to separate

the care from the carer. Himmelweit's point is somewhat similar to the one just made concerning the intimate link between motivation and action in relation to childcare. And yet, childcare is purchased in the market. Indeed, about 20 percent of the households included in the sample for this valuation (details of this sample are provided below) purchase childcare in the market, spending approximately £3,200 per annum (13 percent of these households' annual gross household incomes).[8]

As highlighted above, criticism of input-based approaches has focused on differences in productivity between a worker in the market and a worker in the home (Goldschmidt-Clermont 1993a). In response to this criticism, it has been suggested that the market wage be adjusted to reflect differences in productivity between home and market production (Quah 1993; Abraham and Mackie 2005). These differences are often thought of in terms of the market worker possessing increased knowledge and experience in doing a particular job, so that he or she can complete a given task in less time than the home-based worker or complete a task an individual is incapable of performing by him- or herself. The market, however, cannot provide an hour of childcare any faster than the household, and so there can be no difference in productivity between the home and market if, for instance, speed in completing a task is the criterion by which it is measured.

The market offers a number of replacement options for the time spent in childcare. It would be possible, for example, to take the wage of a general domestic worker who could perform a variety of tasks including childcare. This is known as a generalist replacement cost method. On the other hand, we can distinguish between the different household tasks and choose replacements accordingly. This latter approach is known as a specialist replacement cost method. Childcare again poses unique questions in that, as shown above, it consists of a varied set of distinct activities. Martha MacDonald asks if the value of childcare should "be calculated using the wages of daycare workers or child psychiatrists?" (1995: 164–5). She highlights a feminist critique of efforts to value household production, arguing that unpaid household work is undervalued if depressed wages in the market for work mostly carried out by women are used to value it. Echoing MacDonald's question: should the wage of a childcare worker or that of a teacher be used to value talk-based care? Table 1 reports the distribution of wages in pounds sterling for childminders and related occupations in the childcare sector in the UK in 2005. A childminder cares for a small number of children (up to six) in his or her home. Other related occupations include nannies who care for children in the children's own homes or care workers in childcare facilities. For comparison, the bottom row of Table 1 presents the hourly wages for a teacher in the education sector.

The mean wage for a teacher (£19.30) is almost three times greater than the mean wage for a childminder or a person in a related occupation in the childcare sector (£7.43). There is no doubt that the teacher possesses a

Table 1 Replacement market hourly wages in pounds sterling in 2005 for childcare and teaching services in the UK

	Mean	*Percentiles*				
	–	*10*	*20*	*50*	*75*	*90*
	£	£	£	£	£	£
Childcare sector						
Childminders and related occupations	7.43	4.87	5.50	6.98	8.50*	x
Education sector						
Primary and nursery education teaching professionals	19.30	12.34	15.09	19.30	23.14	27.41

*Coefficient of variation 11–19 percent; x = unreliable.
Source: Office for National Statistics (2005).

certain level of human capital, which is duly reflected in his/her wage. However, the question remains: are aspects of care provided by parents more akin to those provided by a teacher than to those given by a paid worker in the childcare sector? Addressing this question, Nancy Folbre and Jayoung Yoon (2006) assign average wages for a childcare worker to physical care and average wages for a kindergarten teacher to talk-based or "developmental" care. I adopt a similar approach here. The shadow wage assigned to undivided talk-based care is that for a teaching professional at the tenth percentile (£12.34). This approach is more conservative than adopting the mean wage. One reason for doing this is that as a care activity it does remain somewhat diffuse. Craig (2006) argues that developmental care encompasses aspects of care that tend to be more fun and less physically onerous for a parent to provide than other caregiving activities. Therefore, its importance in encouraging children's development, an importance not reflected in the wage offered in the childcare sector, must be weighed against the proposition that it is a type of care that can be less physically onerous to provide. This study assigns the wage of a childminder at the twentieth percentile (£5.50) to supervisory care and combined physical care. This amount is slightly higher than the current minimum wage, which is £5.05 for workers ages 22 and over. For all other care jobs, the shadow wage is the mean wage of a childminder (£7.43). To locate these choices in some context, I assign a shadow wage of £5.00 to provide a lower bound estimate and assign a shadow wage of £9.68, which is the largest reliable hourly wage in the childcare sector (not shown in Table 1), to provide an upper bound estimate.

The total household input of childcare is the sum of each parents' contribution. Some have argued that when employing a replacement cost

approach, as is the case here, the time of only one carer should be valued where two parents are providing care simultaneously (Nancy Folbre, Jayoung Yoon, Kade Finnoff, and Allison Sidle Fuligni 2005). This argument stems from the view that the opportunity cost approach seeks to replace the carer, whereas the replacement cost approach replaces the care actually received by a child. However, either approach seeks to replace the carer, or carers, but they differ in terms of where they hold the source of the value of the time to be: the carer (opportunity cost) or the care (replacement cost). Not counting the total time input of all parents when both are caring simultaneously would effectively render one of the carers redundant. While a firm operating in the market would never hire two carers to look after a single child (at least not without charging uncompetitive rates per child, or paying incredibly low wages), it is not necessary to impose these market conditions onto production within the household. The treatment of periods in which more than one carer is providing care is one that has a direct bearing on output methods but not on the choices between variants within the input method. This will become evident in the examination of the measure of the output of care.

OUTPUT METHOD

The output of childcare

Where the input of childcare is measured from the perspective of the carer, the output of childcare is measured from the perspective of the children being cared for. The output of childcare produced by households has previously been measured as a portion of a child's day (Dalenberg, Fitzgerald, and Wicks 2004). In other words, it is, like the input measure, a quantity of time. Dalenberg, Fitzgerald, and Wicks (2004) obtained data on the proportion of the day each child in a household received care as the primary function from parents, other household members, school, babysitter, childcare facility, other friends and relatives, and finally self-care. They restrict their measure to care carried out as the main activity. To obtain a measure of the output of childcare, working in the opposite direction, I ask: how much time does each child spend with his or her parent(s)? This approach is preferable because it includes time when children are receiving supervisory care, and it obtains information independently from children themselves.

From a child's perspective, there are three possibilities with respect to the time spent with parents in households with two resident parents: (1) with a lone-mother only, (2) with a father only, and (3) with both parents. In lone-mother households, only the first option can be observed with the available data. Acknowledging instances when a child is with both parents together is

crucial in order to avoid double-counting the output, and it is at the core of a fundamental distinction between the input and output measures of childcare. Consider an example of a household with two parents and one child. On one day, each parent provides 1 hour of care at different points in the day, and the child therefore receives 2 hours of care in total. In this instance, the time input is 2 hours (1 hour for each parent), and the time output is 2 hours. On another day, each parent again provides 1 hour of care, but on this occasion the care is provided jointly. Under this scenario, the time input is still 2 hours whereas the time output is 1 hour. This is a crucial difference; ignoring it would result in a violation of the 24-hour time constraint from the perspective of a child who is the center of focus in the output measure. The output for each child is computed as the sum of these three distinct components, a method that permits a straightforward disaggregation of total output into the output that the mother, the father, and both together provide.

Recalling from above, all individuals aged 8 years and over within sample households completed a diary specifying their activities, the people they are co-present with, and their location. Each individual records this time-use information independently and simultaneously throughout the day. To compute the three distinct components of the output measure, I use the co-presence and the location information from both parents and children. It is necessary to use information about location because parents do not specify with which child they are co-present; nor do children specify with which parent they are co-present. One complicating factor is that when individuals are sleeping, engaging in paid work, or in education activities, co-presence and location information are not collected. Paid work is not relevant to children, and sleeping is addressed in a section below. Time when children are in classes is unproblematic as they are in school, but the time they are engaging in homework or study needs to be addressed. A large part of the time engaged in this activity will be carried out when children are near their parents. In order to include this time, location information is imputed.[9]

A child is regarded as being with a mother when the mother states she is co-present with a child, and the child states he or she is co-present with a parent (or at the same location as his or her mother) but not at the same location as his or her father. A child is regarded as being with a father when the father states he is co-present with a child, and the child states he or she is co-present with a parent (or at the same location as his or her father) but not at the same location as his or her mother. A child is regarded as being with both parents if the mother and father both state they are co-present with a child, and the child states he or she is co-present with a parent, and all three are at the same location. A child is regarded as not being with a parent when he or she is not co-present with a parent and not at the same location as any parent.

Children ages 0–7 years are not directly observed, but there are two important pieces of information at hand, which can be used to estimate the output time for these children. The first is the time parents state that they are with children. As with children 8–13 years, it is important to distinguish between time with a mother, a father, or both parents together when considering the output of childcare for those aged 0–7 years. Cross-referencing the diary information from both parents, I measure the time when only a mother is with a child, time when only the father is with a child, and time when both parents are co-present with a child. The output time for children 0–7 years is thought of as proportional to the total of each of these components.

This leads to the second key piece of information that I draw upon to estimate the output for children 0–7 years. This is the total time young people 8–13 years are with or at the same location as either or both their parents. Dividing this through by the sum of time that parents are with a child (not double-counting the time both parents are with a child) transforms the output time for children 8–13 years into a proportion. For children 8–13 years in households where they are an only child, this proportion is 0.8.[10] In other words, on average an only child (8–13 years) is with or at the same location as his or her parents for 80 percent of the total time that each parent individually, plus both together, state they are with a child. Averaged over households with multiple children this proportion is 0.74, which is lower in multichild households because the child a parent records being with may not be a child observed in the data. If we include the time children are sleeping, the proportion of time when parents state that they are with a child rises by about ten percentage points in each instance. This rise notwithstanding, the proportion is clearly less than 1, even in households with a single child. There are a number of possible reasons for this. There is probably a degree of "slippage" in the sequence of activities as they occur across multiple self-completed time diaries. There is also likely to be some degree of measurement error or ambiguity in the records from both parents and children. Parents may also be referring to their own nonhousehold children when they state they are with a child. Finally, it must also be acknowledged that parents may overstate the time they are with their children.

The average proportion for all children 8–13 years of 0.74 provides a lower bound for the imputation to children 0–7 years that, combined with a natural upper bound of 1, leads to quite a narrow range of possible values for imputation. Figure 1 reports the proportions imputed for children 0–7 years combined with those estimated for children 8–13 years. It is interesting to note that the proportion is quite flat for children 8–13 years. I impute the drop in the proportion as children enter school in a gradual fashion so as to reflect gradually increasing school hours. An alternative

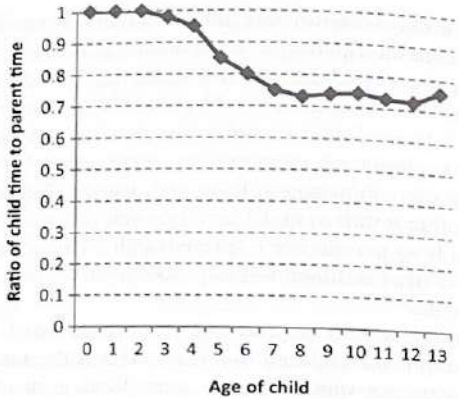

Figure 1 The proportion of the time parents are with children (not double-counting time when both parents are jointly with children) that children state they are with parents: imputed for children 0–7 years and estimated for children 8–13 years

would be to impute a single drop from 1 to 0.75 for children of school age, but this seems implausible.

The output of childcare for children 0–7 years is obtained by multiplying the total time parents of children 0–7 years are with a child (not double-counting the time both parents are together with a child) by the age-specific imputed proportions shown in Figure 1. So, for example, the output for a 5-year-old child will be 85 percent of the total time his or her parents are with the child (not double counting time when both parents are with the child). For a 2-year-old child, the output will be 100 percent.

The price of "per-child" childcare

Examples of childcare provided in the market on a per-child basis include daycare or crèche facilities, nursery school, after-school clubs, and playgroups. Another example in the UK is that of a childminder who looks after a number of children in his or her own home and charges a fee per hour, per child. The National Childminding Association (NCMA) surveys members annually to find out what childminders are charging. In 2004/05 the average across all regions was £2.84 per hour, per child, and the average highest quoted price across all regions was £5.03. Sue Holloway and Sarah Tamplin (2001) construct a child-adjusted hourly wage, dividing the hourly wage of a live-in nanny by the number of children for whom they assume a live-in nanny is caring, which they state is two. Recall from Table 1 that the average hourly wage of a childminder and related occupations was £7.43. In this study, this is divided by the average number of children in the

sample, which is 1.8, giving an output adjusted hourly wage of £4.12. The output-adjusted hourly wage lies between the overall average price of £2.84 per hour and the highest quoted average price of £5.03 per hour.

OVERNIGHT CARE

Childcare is produced in households during the night. Parents and children may both be sleeping, but there are clear examples in the public sphere where caretakers do not cease to provide care for a child when they, the child, or both are sleeping. This type of "on-call" work is also common in other areas, such as the fire service, and it should be included as part of a valuation of parental childcare. I estimate information about the time mothers, fathers, and children 8–13 years spend sleeping from the data. The time mothers and fathers spend sleeping near children is summed to provide a measure of the input time to overnight care. The time all children 0–13 years are sleeping under the care of their parents is summed to provide a measure of the output time of overnight care. I assume that children 0–7 years sleep for about 11 hours on average. Younger infants will probably sleep more than this, and children 4–7 years are likely to sleep less. Reflecting the low-intensity nature of this care, I assign the lowest hourly price (£2.84) to the output and the lowest hourly wage (£5) to the input.

It is important that the sheer volume of on-call care provided during the night does not obscure the dynamics of the inputs and outputs of care provided during the day. For this reason, I keep estimates of the imputed value of overnight care separate from estimates of the imputed values of waking care. A further issue is that the gendered dimensions of care provided during the day may not be replicated in overnight care, as it can be argued that both mothers and fathers contribute equally (provided they are both present); but it is also important to note that it is mothers who are most likely to have their sleep interrupted by a waking child in need of care (Craig 2007). Treating mothers and fathers in the same way is therefore problematic, but there is no option to do otherwise with the current data. This is a clear limitation of the approach adopted here to value overnight care and further necessitates its separation from estimates of the imputed value of waking care.

SAMPLE AND RESPONSE WEIGHTING

The overall response rate for UKTUS is the response rate of households targeted (61.1 percent) multiplied by the response rate of diaries submitted by individuals in these households (72.7 percent), which yields a net diary response rate of 44.4 percent. The methods outlined above exploit the time-use data thoroughly and impose further selection criteria upon the

responding sample. This study selects households from the responding sample if there is diary information available for all parents and all children ages 8–13 in responding households. Households with a child age 14 are excluded. The reason for this is that the categories for co-presence in the parents' diaries used to measure the total input range from 0 to 14 years. But 14-year-olds completed an adult diary and therefore did not record whether they were with their parents, therefore excluding them from the measure of the output of care. The households may contain children ages 15 or older, but this does not affect the co-presence variables used. Furthermore, only households where all respondents completed diaries for both a weekday and a weekend day are included. This is because the annual value is a multiple of the weekly value, which is the sum of weekday and weekend totals. The resulting sample contains 895 households.[11] A lone mother heads approximately one-quarter of the households in the sample, and the remaining households contain two resident parents.

These are very restrictive selection criteria, and I cannot ignore the potential for serious nonresponse bias. I supplied weights to correct for this in the data set as a whole, but it is appropriate to further augment these to take into consideration the added selection criteria. It is apparent from the results of a logistic regression that small families (fewer parents and fewer children) have a higher-than-expected probability of being included in the sample. To correct for this, I constructed a new weight $\hat{W}$, given here as:

$$\hat{W} = [(w/\theta_i) * (P/(\sum_{i=1}^{n} (w_i/\theta_i)))] \qquad [\mathrm{i} = 1, 2, 3, \ldots \mathrm{n}]$$

where w=weight supplied with data; θ_i=predicted probability of being included in the sample; P=population of households with a child age 0–13 years. I multiply the UK population weights in the data (which, when summed across the entire sample, equals the population of UK households) by the inverse of the predicted probability of being included in the sample, which is derived from a logistic regression.[12] I adjust this in turn so that the new weights correctly add up to the total population of households with a child age 0–13 years.

MICRO-LEVEL RESULTS

Table 2 reports the mean value of childcare produced by households in the UK using the input approach that includes all supervisory childcare (Input 3) and the output approach. It is clear that the shadow wage applied to the total input quantity results in a higher value for the input approach, which, not surprisingly, is concentrated in two-parent households. The output method, therefore, presents a more accurate picture of the production of childcare by lone mothers relative to couple households. Increasing

Table 2 Average annual value of Input 3 and Output for households in the UK

	Couple		*Lone mother*		*All households*	
	Input 3 £000s	*Output £000s*	*Input 3 £000s*	*Output £000s*	*Input 3 £000s*	*Output £000s*
Total	31.1	29.1	18.7	21.4	28.8	27.7
Number of children						
1 child	28.1	15.8	17.4	13.0	25.6	15.2
2 children	32.7	33.7	19.2	27.9	30.9	32.9
> 2 children	35.7	56.2	23.9	47.8	33.9	54.9
Age of youngest child						
0–4 years	37.0	37.6	23.3	31.5	34.8	36.6
5–13 years	25.7	21.4	15.6	14.7	23.7	20.1

Notes: In this study, Input 3 was priced using the different wage rates for different care tasks (£6.13 on average), and Output was priced at £5.02 per hour.

numbers of children raise the value of childcare, a result that is most pronounced with the output method. Moreover, in lone-mother households the impact of more children on the value of the output is greater relative to the input. For example, the value of output in lone-mother households with three or more children is 50 percent greater than the value of the input. For two-parent households, it is 36 percent greater. Unsurprisingly, the value of childcare is greater in households with children under 5 years.

Overall, the imputed output value is slightly greater that the imputed input value in these households; however, the difference is more pronounced in lone-mother households. This is probably the result of a combination of having more than one child. In households where all the children are of school age, the output method results in a lower value than the input method. This result is concentrated in two-parent households and highlights the impact of not double-counting the time both parents are together with a child in the measure of the output time. This time when both parents are together with a child is mostly time when parents are not engaging in a specific childcare task and when they are at the same location as the child, a type of care most relevant for older children.

Mothers' and fathers' contribution to the household production of childcare

Table 3 reports the value imputed to the production of childcare by partnered mothers and fathers and lone mothers over a year. Mothers account for approximately two-thirds of the total input value produced in two-parent households. Lone mothers provide a comparable amount of care to their married counterparts. Fathers' mean shadow wage is greater

Table 3 Partnered mothers', partnered fathers', and lone mothers' contribution to Inputs 1–3 and associated mean shadow wages

	Mothers	*Fathers*
Couple household		
Input 1 (£000s)	4.8	2.0
Mean shadow wage	(£8.6)	(£9.2)
Input 2 (£000s)	8.1	3.3
Mean shadow wage	(£7.6)	(£8.1)
Input 3 (£000s)	19.4	11.7
Mean shadow wage	(£6.2)	(£6.0)
Lone mother household		
Input 1 (£000s)	4.4	-
Mean shadow wage	(£8.6)	-
Input 2 (£000s)	7.5	-
Mean shadow wage	(£7.8)	-
Input 3 (£000s)	18.7	-
Mean shadow wage	(£6.2)	-

Notes: Input 1 corresponds to care activities carried out as the sole activity; Input 2 corresponds to care activities carried out as the sole activity and combined with other activities; Input 3 corresponds to all care activities (sole and combined) as well as all supervisory childcare.

than mothers' mean shadow wage in two-parent households for the Input 1 value. Talk-based care is a higher proportion of fathers' total care, and this type of care has been assigned a much higher shadow wage, which explains this difference. Taking all time with children into consideration, mothers' average shadow wage is £6.20 per hour and fathers' average shadow wage is £6.00. Lone mothers' average shadow wage is equal to partnered mothers, and the imputed income from their production of childcare is slightly below that for partnered mothers.

Though clearly highlighting the role of mothers in the production of childcare, focusing on the total input by parents individually ignores the time parents are together providing care. I argue above that this omission is a major factor in the inflation of the input value of childcare produced in two-parent households. To observe the impact of the care overlap on the total value of output in two-parent households, the value of output is disaggregated to show the respective contribution made by mothers alone, fathers alone, and both together. Recall that the output of childcare is computed as the sum of the time each young person receives care from his or her mother only, his or her father only, and both together. This means that the total output can be easily disaggregated to examine the relative contribution of each parent individually and both together. In lone-mother households, only the care provided by the resident mother is included. Table 4 shows the imputed value of the output of care provided by mothers and fathers individually and both together in couple households, and the

imputed value of the output of care provided by lone mothers for each of the three output prices chosen for the imputation.

Mothers in two-parent households are contributing much more to the value of the output, although a large proportion of the household total of output is produced jointly with fathers. For fathers, the influence of joint care on their total contribution is even more substantial. The individual contribution made by lone mothers stands out compared with the contribution made individually by either parent in two-parent households.

MACRO-LEVEL RESULTS

Table 5 reports estimates of the aggregate value of childcare produced by households in the UK as a proportion of GDP 2005 (about £1.2 trillion), with these estimates expressed in billions of pounds. There are nine input-based estimates and three output-based estimates. The nine input-based estimates are composed of the three different measures of parental childcare time and with three imputed shadow wages for each. The three output-based estimates are composed of a single measure of output time along with three imputed market prices for childcare. Estimates for Input 1 range from 1.8 to 3.5 percent of GDP, depending on the shadow wages assigned. This is less than other comparable estimates. For example,

Table 4 Value of output produced by partnered mothers and fathers individually, two parents jointly and lone mothers

	Price = £2.84	*Price = £4.12*	*Price = £5.02*
Partnered mother (£000s)	8.1	11.8	14.4
Partnered father (£000s)	2.5	3.6	4.4
Both parents (£000s)	5.8	8.4	10.3
Lone mother (£000s)	12.1	17.6	21.4

Table 5 Estimates of Input 1, Input 2, Input 3, and Output as a proportion of GDP and in billions of pounds

	Input 1		*Input 2*		*Input 3*		*Output*	
	% GDP	*£s (billion)*	*% GDP*	*£s (billion)*	*% GDP*	*£s (billion)*	*% GDP*	*£s (billion)*
Low price/wage	1.8	22.1	3.6	43.6	11.8	144.3	7.8	95.9
Medium price/wage	3.2	38.9	5.4	65.5	14.4	176.4	11.4	139.1
High price/wage	3.5	42.8	6.9	84.4	22.8	279.5	13.8	169.4

childcare produced by households in Finland was estimated at 4 percent of GDP (Varjonen and Aalto 2006). This Finnish estimate was computed on the basis of all primary activity childcare and not just undivided childcare activities, as is the case for Input 1. Sousa-Poza, Schmid, and Widmer (2001) estimate values that range from 5 to 8 percent of GDP in Switzerland, depending on the choice of shadow wages, with a specialist replacement cost measure producing the highest estimate. This is well above the range of Input 1. Input 2 includes all childcare activities and ranges from 3.6 to 6.9 percent. This range is similar to these other input-based estimates. However, all of these estimates fall well below Input 3, which includes supervisory care. This estimate ranges from 11.8 to 22.8 percent of GDP. Clearly, focusing only on specific childcare activities will result in lower estimates of the value of childcare, especially if the valuation is restricted to undivided care activities.

The output estimates reported in Table 5 are lower than Input 3, but higher than Inputs 1 and 2. Depending on the price assigned, estimates of the value of the output range from 7.8 to 13.8 percent of GDP. Holloway and Tamplin (2001) report an output value of childcare that ranges from 9 to 13 percent of GDP. Taking the output price at £2.84, which is closest to the price they assign, the output value reported in this study is 7.8 percent of GDP. This suggests that the upper ranges of the Holloway and Tamplin (2001) estimate (where they assume lower amounts of unsupervised time) are overestimates. It should also be noted that the Holloway and Tamplin (2001) estimate includes not just parents, but all carers. Furthermore, they value care provided for children ages 0–15 years.

The estimates of both Input 1 and Input 2 fall below the estimates of the output, which is in contrast to previous research showing output-based estimates as lower than input-based estimates (Dalenberg, Fitzgerald, and Wicks 2004). Recall, however, that these researchers' estimate of output does not include supervisory care, which is not the case here. It can be seen in Table 2 that estimates of Input 3 are higher than the largest estimates for the output, thereby echoing previous findings that are based on more restrictive measures. There are a number of points, however, where the estimates of the value of the household production of childcare are approximately the same for both the input and the output method. This occurs when the broadest measure of input time is used, the shadow wage exceeds the price of the output, and the shadow wage is observed at two points.

The first of these points where the two estimates (of the value of parental childcare) are about the same for both methods occurs when the shadow wage is at the lowest point on the range (£5) and the output price is at the midpoint (£4.12). At these prices, the aggregate value of childcare is approximately 11 percent of GDP for both input and output methods. The second point occurs when shadow wages are at their midpoint (£6.13 on

Table 6 Estimates of the value of overnight care

	Output	*Mother input*	*Father input*
Couple household (£000s)	19.3	15.4	14.9
Lone mother household (£000s)	17.2	15.8	–
Proportion of GDP: all households (%)	9.5	7.7	6.1

average) and output prices are at the highest point (£5.02). The aggregate value of childcare from each method at these prices is approximately 14 percent of GDP. This shows that for given measures of input and output childcare time, the imputed value from each approach can approximate the other, provided that shadow wages and prices are permitted to vary within a reasonable range of values.

OVERNIGHT CARE

Table 6 reports the average annual value of output and input in couple and lone-mother households. In addition, Table 6 reports the aggregate value summed over all households as a proportion of UK GDP 2005.

As expected, there is little difference between the input values for mothers and fathers, and there is hardly any difference between lone mothers and parents in two-parent households. One might have expected the output value to be greater than the input values for each parent, but the output values are kept lower due to the lower price assigned to the output. Overall, including time sleeping adds about 9.5 percent to the aggregate value of output.

CONCLUSION

Childcare is unique amongst the households' production set in that the unit of measurement for the chief input is identical to that used to measure output time. It has been shown here that by using time-use information completed by children, an output method can be calculated as well as the usual input method. This means that with appropriate time-use data, it is possible to quantify the inputs and outputs of childcare, thereby advancing efforts to value all household production.

Micro-level results reveal important differences across households of differing composition. Estimates of the input are highly sensitive to the number of parents, and the estimates of the output are highly sensitive to the number of children. These conditions mean that an output measure provides a more accurate estimate for lone mothers' production of childcare relative to that provided in two-parent households. Results also show clearly that women contribute the largest share to the value of the

childcare produced by households. The gendered division of labor in the provision of childcare is shown as most pronounced when looking at the output of childcare, where it is clear that fathers' individual contributions are the lowest. These results also serve to emphasize the large individual burden of care carried out by lone mothers.

A range of estimates for both input and output approaches were presented. The input method using a broad measure of childcare time resulted in a value that ranges from 12 to 23 percent of GDP. Assigning wages so as to differentiate between types and relative intensities of care activities yielded an estimate of 14 percent of GDP. Restricting the measure to all specific childcare activities resulted in an input value of 5.4 percent of GDP, but this value could range from 3.6 to 7 percent. Further restricting the input to include only activities carried out as the sole activity reduced the estimates to a range between 1.8 and 3.5 percent of GDP. The output method provided estimates that ranged from 7.8 to 13.8 percent. Results also showed that the imputed value of childcare from the input method could approximate the imputed value of childcare from the output method.

A critical distinction between the input and the output methods concerned the treatment of the time when both parents provided care simultaneously. With the input method, I ignored this distinction and counted the total time of the mother and the father; whereas with the output method, I did not double-count time when both parents provided care. Though it is entirely proper to count the time in this fashion, the prices and shadow wages I assigned could be adjusted to reflect the varying intensity of the care. A related matter concerns variation in the number of children being cared for at any point in time. Valuations of childcare that take account of variations in the intensity of care when choosing shadow wages and prices are an important further step in advancing the movement toward a full accounting of the childcare produced in households (Folbre et al. 2005; Jayoung Yoon 2008).

One key limitation of a valuation of childcare like the one this study presents is that it cannot take account of variation in quality between home- and market-produced childcare. There are some further limitations in the scope of the present valuation. For example, only children up to the age of 13 years are included, and only the care provided by parents is valued. Clearly, older children up to about 15 years are also the recipients of care, and other family members or co-resident adults may provide care. A further limitation is that households are treated as isolated units, and only resident children and parents are considered in the valuation. Care arrangements for children often go beyond the confines of a single household. Children may move across the households of different parents when partnerships dissolve. Nonresident grandparents or other relatives may also play a key role in the care provided to children. Therefore, the total care children

receive may be spread across more than one household. A fully comprehensive valuation of all childcare would include care provided by parents to children who do not live regularly in the parents' household, as well care that grandparents or other relatives may provide to children who sometimes, but not always, live in their households.

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NOTES

[1] Colin Clark (1958) credits Arthur Cecil Pigou with the classic jibe.

[2] It is estimated that government expenditure in the UK could be about 2.2 percent of GDP (2004/05 level) by 2020 for early years childcare provision, placing the UK on par with current provision in some Scandinavian countries (Daycare Trust 2004).

[3] See also Luisella Goldschmidt-Clermont (1990); Ann Chadeau (1992); Euston Quah (1993); International Research and Training Institute for the Advancement of Women (INSTRAW; 1995, 1996); Duncan Ironmonger (1996); Marilyn Waring (1999); Steven J. Landefeld and Stephanie H. McCulla (2000); Sue Holloway, Sandra Short, and Sarah Tamplin (2002); Katharine G. Abraham and Christopher Mackie (2005).

[4] The market-based accounts use three methods in total, the third being the production account, which is the sum of the value added at each successive stage in the production process. Taken together the three accounts must balance, thereby providing a triangulated observation of the value of market production at any point in time.

[5] Note that in this study "Accompanying a child" is almost always recorded as a primary activity. The few instances that it is recorded as secondary are added to the time that is recorded as primary.

[6] This method follows directly from the household production function developed by Gary Becker (1965).

[7] This issue of process benefits was first raised by Robert A. Pollak and Michael L. Wachter (1975), who referred to it as joint production, in a critique of Becker's (1965) model. They highlighted that as well as using time to produce utility-yielding commodities, the use of time itself produced utility, thereby resulting in a type of joint production.

[8] This study uses imputed variables for household income and childcare expenditure that were later appended to UKTUS 2000 to produce these results. See Tania Burchardt (2006) for details.

[9] The method of imputation involves looking at the episode location of the young person before and after the episode of homework or study. In cases where the episode location before and after the episode of homework or study is identical, this is the location that I impute. Where traveling is recorded before the episode, I impute the location after the episode of homework or study. Where traveling is recorded after homework or study, I impute the location before the episode of homework or study. These imputations provide location information for about 94 percent of all episodes of homework or study.

[10] See Appendix Table 1 for details of the sample I used to compute these ratios.

[11] Altogether, 915 of the responding households meet these selection criteria, but twenty lone-father households are dropped from the sample. As a distinct group they are too small for meaningful analysis, and combining them with lone mothers to create a "lone-parent" group would be misleading given that the vast majority of this group would in fact be lone mothers.

[12] These regressions initially included gross household income, housing tenure, and the availability of a car. None of these was statistically significant, and they were dropped from the regression. The final specification included number of parents, number of children, and the age of the youngest child in the household.

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Appendix Table 1 Sample used to compute the proportion of the adjusted input factor

		N
Number of children		1,000
Age	8	167
	9	160
	10	184
	11	174
	12	157
	13	158
Gender	Male	494
	Female	506
Diaries	Weekday	100
	Weekend	98
	Both	802
Number of parents	Two resident parents	762
	Lone mother	238

Notes: Children are selected provided they can be matched to all resident parents, and the diaries of the children and all parents contain no more than two hours of missing time.