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CHILD DEVELOPMENT AND COGNITIVE OUTCOMES: THE ROLE OF PUBLIC AD FAMILY INPUTS

Tesi di Dottorato di: Ylenia Brilli

Matricola: 3703815

Anno Accademico 2011/12

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Ringrazio i miei genitori su cui ho potuto contare
in ogni momento di questo lungo viaggio.
Mi hanno accompagnato in ogni città in cui sono stata,
da Milano a Roma a Torino fino a New York!
Ed è grazie a loro che mi sono potuta sentire sempre a casa.
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e che ringrazio anche per il suo supporto tecnologico!

"It is only with the heart that one can see rightly; what is essential is invisible to the eye."

"What is essential is invisible to the eye," the little prince repeated, so that he would be sure to remember.

"It is the time you have wasted for your rose that makes your rose so important."

"It is the time I have wasted for my rose–" said the little prince, so that he would be sure to remember.

"Men have forgotten this truth," said the fox. "But you must not forget it. You become responsible, forever, for what you have tamed. You are responsible for your rose..."

"I am responsible for my rose," the little prince repeated, so that he would be sure to remember.

Antoine-Marie-Roger de Saint-Exupèry,
The Little Prince, Chapter XXI.

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e per avermi insegnato cosa significhi compiere insieme ogni passo.
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Co-authorship disclaimer

The second chapter of this thesis is a joint work with Daniela Del Boca and Chiara Pronzato (University of Turin and Collegio Carlo Alberto). Daniela Del Boca mainly contributed to the theoretical framework, while me and Chiara Pronzato mainly worked on the empirical strategy and estimation.

The second chapter is a substantially revised version of the working paper previously circulated as IZA Discussion Paper No. 5918.

Preface

Starting with Becker (1964), traditional economics of education has pointed out that the returns to investments in early childhood are likely to be relatively high, simply because of the long time in which to reap the rewards. Carneiro and Heckman (2003) develop further this argument, arguing that investments in early childhood are not affected by an equity-efficiency trade-off and mostly respond to equity reasons. Cunha and Heckman (2010) point out that skills produced at one stage augment the skills obtained at later stages and increase the productivity of later investments. These features produce the mechanisms through which skills beget skills, so that the rate of return of investments done at early years is higher than the one of investments made later on (Heckman, 2008). Equalizing this rate of return to a fixed rate representing the opportunity cost of funds in the capital market yields the optimal investment level across child's life: the optimal investment in the child's human capital should be higher when the child is in preschool age and decreasing over time (Carneiro and Heckman, 2003). On the grounds of equity, this result suggests that a remediation for disadvantaged children would be less costly and would have higher returns if made in early years of the life cycle (Almond and Currie, 2011, Bennet, 2008).

Another strand of this literature assesses that children's skills during childhood are strongly related with subsequent outcomes in labor market and social life (Currie and Thomas, 2001, Heckman, Stixrud, and Urzua, 2006). Even though causality is difficult to ascertain, these studies show that child cognitive achievements are strong predictors of a variety of outcomes in later life, such as college attendance and wages. Hence, skills that are used, with different weight in different tasks in the labor market and social life, are produced long before children start kindergarten.

All these results highlight the need to better understand the determinants of early test scores and to assess the effects of investments in human capital made when the child is very young.

Following the notation proposed by Haveman and Wolfe (1995), there may be two main actors involved in the determination of human capital investments during early childhood: (i) the society or government, that provides policies for very young children; (ii) the household, whose decisions concerning time and good allocation affect subsequent child's development. More precisely, while the household decisions can have an effect on subsequent child's outcomes, representing a form of investment in child's human capital, the household decision rule can be also influenced by the opportunity set available for the family members, as provided by the government or the society.

This thesis studies the effects on child development of both policies providing external child care services and household decisions concerning the use of non-parental child care.

During the last decades, there has been a growing interest among economists for the effects of maternal employment and non-parental child care on child development. This has been mostly justified by the increase in maternal employment rate and the subsequent use of external child care that have characterized all developed countries and that have raised concerns for the effects they may have on child development.

While several psychological studies argue that maternal employment determines insecure mother-child attachments (NICHD, 1997, Varin, 2007), implying a negative effect for child development, the economic literature reports mixed findings and these negative effects are far from being confirmed. For instance, Ermisch and Francesconi (2005) report that maternal employment estimates range from being detrimental (Baydar and Brooks-Gunn, 1991, Belsky and Eggebeen, 1991, Bernal, 2008, Chase-Lansdale, Desai, and Michael, 1989, Ruhm, 2004) to having no effect (Blau and Grossberg, 1992, Chase-Lansdale, Moffit, Lohman, Cherlin, Coley, Pittman, Roff, and Votruba-Drzal, 2003, James-Burdumy, 2005) to being beneficial (Parcel and Menaghan, 1994, Vandell and Ramanan, 1992). As pointed out by Almond and Currie (2011), maternal employment matters since it changes the inputs combinations chosen by the parents and according to what are the alternative forms of care used for the child. Despite there being several studies assessing the effects of non-parental child care on child development, also in this case the findings are mixed. Some studies referred to the U.S. (Bernal and Keane, 2011, 2010) find that having attended child care before kindergarten reduces children's test scores. Other studies find instead positive results (Currie and Thomas, 1995, 1999, Deming, 2009, Loeb, Bridges, Bassok, Fuller, and Rumberger, 2007).

The estimation of the impacts of non-parental child care use is hampered by two main issues: (i) the scarcity of data on all relevant inputs for child development, *in primis* on time and goods inputs; (ii) the endogeneity issues due to the correlation of the non-parental child care choice with unobservables of both parents and children (Bernal and Keane, 2010), as well as with other choices made within the household, e.g., maternal employment. The diversity of the results found in the literature may depend on the different outcomes considered in the analysis, as well as on the diverse data sources or country evaluated, or on the different strategy used to handle the sources of endogeneity. Moreover, all the studies evaluating the impact of external child care on child development use proxies for the goods and time investments of parents, since this information is often incorrectly measured or absent in survey data.

This thesis is composed by three distinct, although complementary, chapters dealing with the effects of non-parental child care policies and use for subsequent child development. It contributes to the existing literature on the effects of non-parental child care on child development in the following ways. First, reviewing the most recent results on the effects of large-scale child care policies, it shows that the diversity of the results may also depend on the different institutional context and public intervention in the child care service: in fact, while the decision to use non-parental child care remains up to parents, public intervention in child care provision or regulation can change the opportunity set available to them. Second, it provides further evidence of this finding studying the effects of a child care policy in a country characterized by very low public investments in early childhood education, i.e., Italy. Third, it estimates the effects of several decisions made

within the household, i.e., non-parental child care use and maternal employment, using a relatively new empirical strategy and exploiting a unique dataset that allows to use an actual measure rather than a proxy of the time inputs received by the child.

Chapter 1 provides a review of the most recent studies evaluating the impacts of external child care, with a focus on policies providing non-parental child care. Although there being surveys dealing with the determinants of child development (Haveman and Wolfe, 1995) or reviewing the impacts of early childhood programs targeted toward very young children and mostly implemented in the U.S. (Almond and Currie, 2011, Cunha, Heckman, Lochner, and Masterov, 2006), a review of the most recent findings referred to other European or Latin American countries is lacking. The empirical findings of these studies are conceptualized in a simple theoretical framework showing how parents' decisions and policy intervention interact in contributing to child's development. The aim of this review is to show the role played by the institutional context where the policy has been implemented and the timing of the intervention. Taking into account these features, European studies evaluating the effects of public child care policies providing high-quality services agree on their positive effects for children's development, especially for children belonging to low socio-economic backgrounds (see, for instance, Datta Gupta and Simonsen (2011a) for Denmark or Havnes and Mogstad (2010, 2011b) for Norway).

Chapter 2 presents a study assessing the impact of public child care coverage in Italy on both mother's employment status and children's cognitive development.

Non-parental child care can have a custodial role supporting mothers' participation in the labor market but also an educational one, contributing to children's cognitive and noncognitive development and leading to gains in the accumulation of human capital in the society. This study provides first evidence on both the custodial and the educational roles of child care in Italy, evaluating its effects on both mother's employment and child's cognitive outcomes at school. The analysis is performed using newly available data provided by INVALSI (the Italian Institute for the Evaluation of the Education System) and referred to the school year 2009-10, matched with data on child care coverage at province level provided by Cittadinanzattiva (2007). Italy is an interesting case study, since child care availability covers only 12 percent of children aged between 0 and 2 (ISTAT, 2011), and demand for a child care slot outnumbers supply everywhere (Zollino, 2008): according to a recent report from Cittadinanzattiva, only 20 percent of potential demanders can have a place in a public structure, while this figure is more than 50 percent for Denmark and Sweden and between 25 and 50 percent for France and the U.K. (Cittadinanzattiva, 2012). The female employment rate is endemically low with respect to other European countries and to the U.S.: the participation rate of mothers with children aged 0-2 is equal to 47.3 percent, while for Denmark and Sweden it is around 71 percent and 54 percent for the U.S. and France (OECD, 2007b); between 20 and 30 percent of mothers leave the labor market after the birth of the first child (Bratti, Del Bono, and Vuri, 2005, Casadio, Lo Conte, and Neri, 2008). Furthermore, according to 2006 data from PISA (the Programme for International Student Assessment), 15-year-old Italian students rank fourth from the bottom in average educational performance among advanced countries (OECD, 2007a). Due to the scarce availability of the service, the municipality, that is the main decision-maker for

the child care policy, decides how to allocate the available slots using eligibility criteria. These criteria may respond to a custodial role for the service, if priority is given to working mothers, or to an educational one if they give priority to children belonging to poor socio-economic backgrounds. The decisions of the municipalities regarding the number of child care slots to supply is very likely to depend on their preferences, concerning the type of households to target the service. If the availability of child care slots is not sufficient to cover the demand, the municipalities can use rationing, i.e., eligibility criteria, as a mean to maximize their objective function and to give priority to some households instead of others. In this case, the additional slot can be targeted toward families and children who may benefit more from it. For this reason, the relationship between child care coverage and both the outcomes (i.e., maternal employment and child cognitive outcomes) is very likely to be non-linear and the effects of a percentage change in public child care to be greater when child care coverage is lower.

Chapter 3 presents and estimates a behavioral model, used to assess the effects of maternal decisions (i.e., employment, non-parental child care and time with the child) on subsequent child's development. The main contribution of this chapter is that it exploits unique data on the amount of time spent by the mother with the child to assess the impacts of maternal employment and external child care use on child development: this permits to avoid using a proxy for maternal time, as it has been done in the literature so far. The model is estimated using U.S. data from the Panel Study of Income Dynamics (PSID) and the Child Development Supplement (CDS) conducted in 1997, 2002 and 2007. The CDS provides retrospective information on all child care arrangements used since birth and widely-recognized measures of child's cognitive outcomes; the Time Diary (TD) section provides unique data on the amount of time the child spends with the mother. Structural estimation is used to recover the effects of all maternal choices and has several advantages with respect to reduced form approaches. First, it allows to model the different sources of endogeneity arising in this framework, due to the correlation of the choices with unobservables of both mothers and children. Second, it permits the definition of the maternal decision making process for more than one endogenous choice: this point is relevant in this framework, since the choice of using external child care is strictly related to the maternal employment decisions. Third, structural estimation provides parameters from theoretical model that can be used to simulate the effects of related policies. In the existing literature on non-parental child care, only Bernal (2008) uses structural estimation to assess the effect of non-parental child care and maternal employment on child development. Assuming that the actual time spent by the mother with the child can be proxied by the time the mother spends out of work, she finds that one year of maternal employment and external child care reduces children's cognitive outcomes by 1.8 percent. The analysis performed in this chapter allows the estimation of the productivity of both maternal time and external child care time. The results show that, for an equal amount of maternal time and external child care time, the marginal productivity of maternal time is slightly lower than the one of external child care. Hence, if the mother works, a reduction in child's ability induced by a reduction in maternal time can be fully compensated for if the child spends the same amount of time in external child care. Thus, maternal employment is not detrimental for

child development. This finding shows that, using a real measure of maternal time instead of a proxy, the negative results previously found by Bernal (2008) are reversed.

CHAPTER 1

Public and parental investments on children. Evidence from the literature on non-parental child care

ABSTRACT - This chapter summarizes the most recent empirical research on parental and social investments in children, with a focus on policies providing non-parental child care. The empirical findings are conceptualized in a simple theoretical framework showing how parents' decisions and policy intervention interact in contributing to child's development. The results from these studies are presented taking into account the institutional context where the policy has been implemented and the timing of the intervention. The majority of large-scale policies providing non-parental child care have positive effects on children's cognitive outcomes, both in the short and in the medium run. Early childhood policies can have long-lasting effects on adult outcomes, also boosting the development of noncognitive skills, that are used and rewarded in labor market and social life.

JEL Classification: J13, I24, I38

Keywords: child care, child development, review, public intervention

1.1. Introduction

In the last decades there has been a large growth in the body of social science research that investigates the effects of parents' behavior on children's development. This literature has also focused on maternal employment and on the consequences of externalizing child care activities, especially during the child's first years of life.

Despite the concerns related to the mother's participation in the labor market, the findings from this literature are mixed. Ermisch and Francesconi (2005) summarize existing studies evaluating the impact of maternal employment on several child's outcomes, as children's attainments and years of schooling, and report that maternal employment estimates range from being detrimental (Baydar and Brooks-Gunn, 1991, Belsky and Eggebeen, 1991, Bernal, 2008, Chase-Lansdale et al., 1989, Ruhm, 2004) to having no effect (Blau and Grossberg, 1992, Chase-Lansdale et al., 2003, James-Burdumy, 2005) to being beneficial (Parcel and Menaghan, 1994, Vandell and Ramanan, 1992). The development psychology literature suggests that if the mother works, this may cause insecure mother-child attachments, which are formed in the first years of a child's life; in other words, the detrimental effect can be due to the loss of time the mother spends with the child. Rarely, this negative impact is compensated by a positive income effect, due to the higher household income related to the mother's participation in the labor market. Almond and Currie (2011) argue that maternal employment really matters for child development as long as it changes the inputs combination chosen by parents and according to what are the alternative forms of care used for the child. The issue is then whether non-parental child care can have positive or negative impacts for child development when the mother works.

Recently, a related literature assessing the impacts of non-parental child care on child's development has emerged. These studies consider very different outcomes and do not provide homogeneous results. Some of them referred to the United States (Bernal and Keane, 2011, 2010) find that having attended (any) child care before kindergarten induces a reduction in children's test scores by 2 to 3 percent, while Baydar and Brooks-Gunn (1991) find a more detrimental effect if non-parental child care is used during the child's first year of life. Other studies, referred to the same country, find positive results. For instance, Loeb et al. (2007) find that children who attended a center-based arrangement, compared to children cared for by their parents, have reading scores higher by 1.1 points and Math scores higher by 2 points. Currie and Thomas (1995, 1999) and Deming (2009) evaluate the effect of having attended Head Start and find positive differences in test scores between those who attended the program and those who did not.

The reasons for these disparate findings are multiple, and range from the different child's outcome measure that is used, to the diverse data source considered and to the different empirical strategy handled to estimate the parameter of interests. More importantly, the variation in these estimates can also depend on the different institutional contexts and the characteristics of the service that is analyzed.

Only very recently a similar literature has evaluated non-parental child care impacts in Europe and other countries, different from the U.S.. These studies focus more on publicly provided large-scale programs and the majority of them suggests positive implications of highly regulated services for children's development, especially for children belonging to

the most disadvantaged backgrounds. The present survey aims to present an overview of these newly available results, focusing more on studies evaluating large-scale child care and preschool programs and stressing the importance of institutions and government intervention for child care to have an effect on child development.

As pointed out by Haveman and Wolfe (1995), investments on children's human capital depend on two main factors:[1] (i) the society or government that determines the opportunities available to both children and their parents (*social* investment), and (ii) the choices made by the parents regarding the family time and resources devoted to children (*parental* investment). This distinction is particularly suitable for non-parental child care, where the choice of whether to use external forms of care remains up to parents, but the government can influence this choice changing the opportunity set available to them and the quality of the service they can buy.

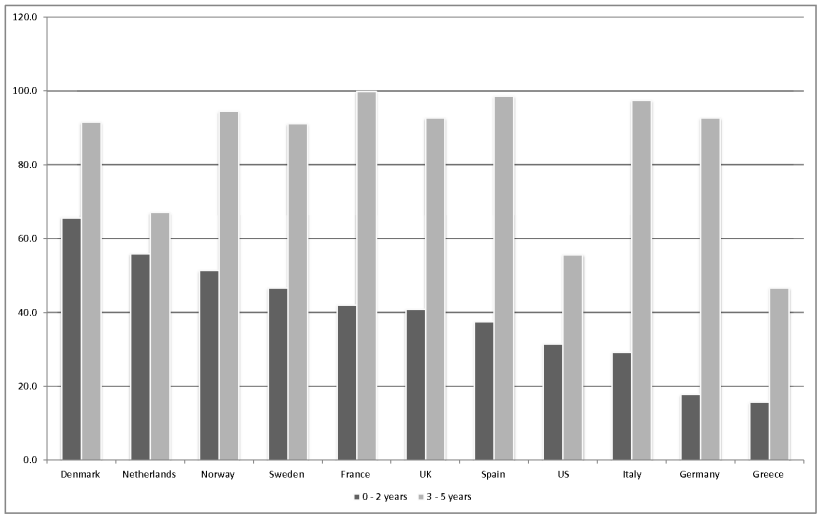
The countries to which existing studies on non-parental child care refer are characterized by very different institutional frameworks, especially in terms of government intervention in child care policies. The first difference to note is on the ground of formal child care and preschool enrollment. As shown in figure 1.1, enrollment in formal (public and private) preschool is higher than 60 percent in almost all countries, but enrollment in nurseries is more differentiated. There are countries, such as Denmark, the Netherlands and Sweden, where more than 50 percent of children younger than 2 attend a formal facility, while in others (e.g., Spain, Italy and U.S.) this percentage drops to less than 30. These figures are the outcomes of both parental attitudes toward external child care and the real availability of formal services. In fact, these percentages represent just a lower bound of the true external child care use, ignoring all households using informal arrangements provided by relatives, friends or babysitters.

Moreover, the structure and characteristics of the child care systems differ significantly across these countries. More precisely, government intervention can imply the direct provision of the service, its regulation or just its subsidization. In U.S. and U.K., the child care market is characterized by a large participation of the private sector, while government intervenes through subsidies in order to assist poor households to afford child care expenditures. In these countries, a distinction aimed to identify services with better quality and stricter regulation is the one between center-based and informal arrangements. However, there are also examples of public intervention in some U.S. states. For instance, pre-kindergarten services are universally provided to children with at least 4 years of age in several states; there are also programs targeted to poor and disadvantaged families and children.[2] In Europe, instead, governments are more involved in the provision and regulation of the service and the supply from the private sector is very limited. There are also differences across European countries: countries in Northern Europe - such as

[1]Haveman and Wolfe (1995) consider a third factor influencing children's attainment, i.e., the decisions made by the child himself once he reaches adolescence. Since this review deals with non-parental child care choices that are mostly taken by parents when the child is in preschool ages, this factor is neglected. However, as the child grows up, the decisions made by the child himself play a stronger role. Cardoso, Fontainha, and Monfardini (2010) and Del Boca, Monfardini, and Nicoletti (2012) analyze this topic.

[2]Concerning universal pre-kindergarten, the Georgia Pre-K program, started in 1995, and the Oklahoma Universal pre-kindergarten, started in 1998, represent some examples. Instead, the Perry Pre-School, Abecedarian and Head Start programs are targeted toward disadvantaged families and imply different degree of involvement for both parents and children. See Almond and Currie (2011) and Cunha et al. (2006) for further details.

Figure 1.1
Enrollment rates of children under age 6 in formal care or early education services, 2008.



Sources: OECD Education database. Formal care and early education services include both public and private facilities.

Sweden, Denmark and Norway - are characterized by universal public child care services, while countries in Southern Europe - such as Italy - are moving toward a mixed child care supply, where both private and public sectors are involved, and all providers are regulated in order to respect minimum quality standards. This difference can also be seen looking at the levels of government spending for pre-primary education. Northern-Europe countries spend around 100 thousands Million Euro for pre-primary education, while countries in Southern Europe spend less than 10 thousands Million Euro.[3]

The differences in the institutional contexts and in the features of the child care systems should be taken into account when evaluating the impacts of child care attendance on subsequent child's development. It is widely recognized that child care should be of high-quality in order to be effective for child development, even though it is not clear which characteristics of the service should be regulated to respect this requirement.[4] Non-parental child care may also have different implications for the development of cognitive and noncognitive skills, since diverse features may affect differently each type of ability. For example, center-based group arrangements, characterized by stricter regulation, may be more effective for the development of cognitive skills and child's readiness to school; however, in case of higher child-staff ratio, they may fail in contributing to the child's

[3]Specifically, Norway spends 50 thousands Million Euro per year, while Sweden have the highest expenditure level of 170 thousands Million Euro. France expenditure is about 13 thousands Million Euro, while Italy and Spain spend only 6 thousands Million Euro for pre-primary education. Own elaboration on data from OECD and Eurostat referred to 2008.

[4]For instance, Blau (1999a) studies the effect of several child care features, usually regulated by the policy maker (e.g., group size, child-staff ratio, teacher education and training, etc) on child's cognitive development and find no statistically significant effects for any of them. Blau and Currie (2006) argue that there may be two dimensions of quality: one characterized by these observables features, and the other, mostly unobservable, related to the quality of interactions between the provider and children. The latter seems more effective for child's development than the former.

vocabulary and language skills, for which the child needs more interactions with only one person. Group-based services can improve child's socialization with other children, while they may be detrimental if the child needs special attention by a single minder. Finally, formal child care is likely to reduce the importance of family background for child development by serving as a substitute for parental care or informal care arrangements, contributing to reduce inequalities and providing better opportunities to children living in low socio-economic backgrounds (Almond and Currie, 2011).

This survey builds on three previous studies that have reviewed part of the broad literature on child development. Haveman and Wolfe (1995) provide an excellent survey of the determinants of children's attainment focusing on family and neighborhood investments. They consider studies evaluating the determinants of economic mobility, high school graduation, years of schooling, out-of-wedlock fertility during adolescence and adult earnings. However they do not explicitly deal with the role of public policies and school and do not consider non-parental child care as an input in the production of child's human capital. Almond and Currie (2011) provide an extensive review of studies evaluating child care impacts focusing on investments made during the first 5 years of life of the child. Specifically, they analyze both non-experimental studies, where the child care treatment is usually every type of non-maternal child care, and experimental analyses, where specific programs targeted toward disadvantaged children and families were considered. All these studies refer to the United States, while the authors, as well as Blau and Currie (2006), recognize the importance of reviewing also studies referred to other countries. Moreover, results from both experimental and non-experimental studies can provide limited information to the policy maker as long as it is not possible to identify precise features of the input, and results from targeted programs can rarely be extended to other contexts. Also Cunha et al. (2006) provide a survey of existing studies evaluating the impacts of targeted programs implemented in the U.S.. They also present a framework modeling the child's development process and based on the idea that agents possess a vector of skills of two types: cognitive and noncognitive. They suggest that cognitive ability, although necessary for success in life, it is not sufficient and that noncognitive skills also matter for education and labor market outcomes (Heckman et al., 2006).

This review mostly follows Ermisch and Francesconi (2005), in that it considers the impact on child's development of a specific input, i.e., non-parental child care. The contributions to the existing surveys are multiple. First, it provides a unique description of studies mostly referred to countries different from the U.S.. To the best of my knowledge, a comprehensive literature review dealing with child care impacts for countries different from the U.S. is lacking. This point, together with the inclusion of more recent analyses, allow to present the non-parental child care impacts taking into account the institutional framework where the service is offered and the policy is implemented. Moreover, considering different contexts allows to test the consistency of the results across countries. Second, the results are presented according to the timing of the investments and in such a way to take into account the contribution to both cognitive and noncognitive child's skills. In fact, the studies analyzed here use different outcomes, measured in diverse stages of the child's life. The structure of this survey takes into account the fact that non-parental child care impact may change over time and may influence in a different manner the development

of cognitive and noncognitive abilities. Among the surveys presented before, only Cunha et al. (2006) recognizes the importance of early childhood intervention for noncognitive skills.

The rest of this chapter develops as follows. Section 1.2 presents the theoretical background for the impacts of child care policies on child's development: section 1.2.1 describes the economic rationals under which government participation in the child care market is justified; section 1.2.2 presents a theoretical model where the parents decide the non-parental child care input for their children and discusses the plausible patterns of the child care impacts over time. Section 1.3 presents the empirical issues arising for the estimation and identification of non-parental child care impacts. Section 1.4 presents the results from selected studies, distinguishing between outcomes measured during early childhood (section 1.4.1), middle-childhood and adolescence (section 1.4.2) and adulthood (section 1.4.3). Section 1.5 concludes.

1.2. Theoretical background

Economic theory provides a framework for the evaluation of child care impacts on child's development, that helps in understanding the results from the empirical studies. As already stated, child's development depends on two main factors: (i) the government or social intervention, that determines the opportunities available to parents and children, and (ii) the parents, that decides their investments on child's human capital. This distinction is particularly important for the non-parental child care decisions, since the actual choice of the parents depends on their opportunity set, that can be manipulated through government intervention. Although not being a pure public good, public intervention in the provision, regulation or subsidization of the child care service is justified by the presence of several market failures that prevent parents from optimally investing in the human capital of their children. Subsection 1.2.1 discusses the economic framework under which the government intervention in child care policies is justified. Subsection 1.2.2 presents a model describing the parental decisions to use external child care and the plausible patterns with which this investment can affect child's development over time.

1.2.1. Rationals for government intervention in the child care market. The first justification for government intervention in child care provision is on the grounds of equity. A government that is concerned with equity can compensate for differences in final outcomes, attempt to equalize initial endowment or both. However, investing in early childhood programs can be more cost-effective and impede the moral hazard problem that may arise when society attempts to compensate people with poor outcomes (Blau and Currie, 2006). Moreover, as suggested by Cunha et al. (2006), human capital accumulation has a dynamic feature that has implications for how investments in human skills should be distributed over the life cycle. Heckman (2008) shows that the rate of return of human capital investments during early years is higher than the one of investments made later on. Equalizing this rate of return to a fixed rate representing the opportunity cost of funds in the capital market yields the optimal investment level across child's life: the optimal investment in the child's human capital should be higher when the child is in preschool age and decreasing over time (Carneiro and Heckman, 2003). The same reasoning justifies public child care as a remediation for children living in poor socio-economic conditions.

In fact, living in disadvantaged conditions in the first years of life can be detrimental for children's future development; public child care may provide them with better educational opportunities with respect to the ones they could get at home (Bennet, 2008).

The second argument according to which government should intervene in child care provision and regulation is on the grounds of efficiency. In fact, public intervention serves to compensate for the existence of market failures, such as liquidity constraints, credit market imperfections and asymmetric information.

Liquidity constraints of the household where the child resides may prevent parents from investing in the human capital of their children and from choosing high-quality child care services; hence, if only private child care is available, only parents highly valuing the educational purpose of child care and with higher willingness to pay can use it. Carneiro and Heckman (2003) show that liquidity constraints may have worst effect for child development if they occur in the first years of the child's life and these negative impacts may persist in the long-run. Similar patterns are related to the inefficiency and imperfection of capital markets. In fact, if capital markets are efficient and the endowed ability of children is observed by the parents, parents could borrow against the future earnings of their offspring, in such a way to achieve the optimal level of human capital during early childhood. Since credit markets are imperfect and there is no commitments on the offspring to give back their earnings to their parents, parents can invest in their children's human capital only reducing their actual consumption; hence, parental income becomes a determinant of children's attainments (Haveman and Wolfe, 1995). Both these issues justify government intervention in terms of subsidization of the services, but do not say nothing about public provision and regulation. However, Bergmann (1996) argues that traditional arguments in favor of cash transfer over in-kind services do not apply to merit goods, such as external child care: in fact, parents may spend the cash grant received by the government in services different from child care or they would not be able to choose the better option for their children. Instead, government provision or, at least, regulation of the service ensures homogeneous standards and well regulated options for the parents.

In fact, public involvement in child care supply is also justified on the existence of asymmetric information of the parents, that leads to inefficient demand and supply of the service. As several studies argue (see, for instance, Blau and Currie (2006) for the U.S. or Bosi and Silvestri (2008) for Italy), parents may not fully account for the benefits of high-quality child care for children; this implies, on average, a lower willingness to pay of the parents and an higher incentive for the child care provider to offer a low-quality service. In order to ensure higher and more homogeneous quality, the government can directly provide the service or establish minimum requirements that should be respected by all child care providers (both private and public).

1.2.2. Non-parental child care choices and child's development. The majority of existing studies evaluating the impact of child care attendance on subsequent child's outcomes interprets child care as an input in the Education Production Function (EPF) framework. Child's ability is the outcome of a cumulative process of knowledge acquisition, fostered both by family and school inputs, and of child's specific initial endowment (Cunha and Heckman, 2008, Todd and Wolpin, 2003). Non-parental child care, as well as the time and goods the parents spend for their child, are the inputs chosen by parents. This

relationship can be summarized by the following expression:

$$A = A(c, \tau, g, \mu) \tag{1.1}$$

where child's ability is a function of non-parental child care c, parental time τ, the goods bought for the child and effective for his own development g and μ, that represents the child's initial endowment. For the purposes of this survey, A represents both cognitive and noncognitive skills. The majority of studies estimate (1.1) or an approximation of that, without taking into account that the inputs c, τ, g are chosen by parents. However, the parents' decision making process should be taken into account when interpreting the empirical results.

The economic modeling explaining how the c, g, τ choices are made derives from the model developed by Becker and Tomes (1986), where the members of the household produce a commodity, i.e., child's ability, by combining inputs of goods and time, as in a firm production process. In this framework, the household maximizes a unitary utility function with child's ability as an argument, and subject to a production function for child's ability with inputs including time of family members, purchased goods and non-parental child care.[5]

The model can be written as:

$$max_{h,c,\tau,g} \;\; u(l, C, A) \tag{1.2}$$

$$s.t. \;\; TT = l + h + \tau \tag{1.3}$$

$$C = HI - pc - g \tag{1.4}$$

$$A = A(\tau, c, g) \tag{1.5}$$

where (1.2) represents parents' utility as a function of their leisure time l, their consumption C and the ability of their child A. Expressions (1.3) and (1.4) are the time and budget constraints, respectively. Notice that household expenditures include consumption, expenditure for external child care (where p is the price of child care) and for the goods bought for the child g, whose price is normalized to 1. Finally, (1.5) represents the child's ability production function. In this model the parents decide their own labor supply h, how many hours to spend with the child τ, how many hours of child care to use c and how many goods g to buy for the child; TT is the total time endowment, HI is total household income, including mother's and father's labor income as well as non labor income.

Assuming separability of goods in the utility function and of inputs in the child's ability production function, the FOC for the demand of child care is given by:

$$c^* \rightarrow -U'_C p + U'_A A'_c = 0 \tag{1.6}$$

[5]This approach assumes that the household maximizes a unitary utility function, implying that all members in the family share the same preference patterns and have a common knowledge of inputs productivities and child's initial endowment. An alternative implementation consists of assuming that there is a dictator, i.e., the mother, who makes choices based on his own preferences. Even though several criticisms to these assumptions have been made by those viewing family decisions as the outcome of bargaining within the household (see Vermeulen (2002) for a review on collective household models), this approach remains the unique used in this literature.

where U'_C represents the first-order derivative of the utility function with respect to consumption, U'_A represents the first-order derivative of the utility function with respect to ability and A'_C indicates the marginal productivity of non-parental child care input.

After some rearrangements, the demand for child care is given by the following condition:

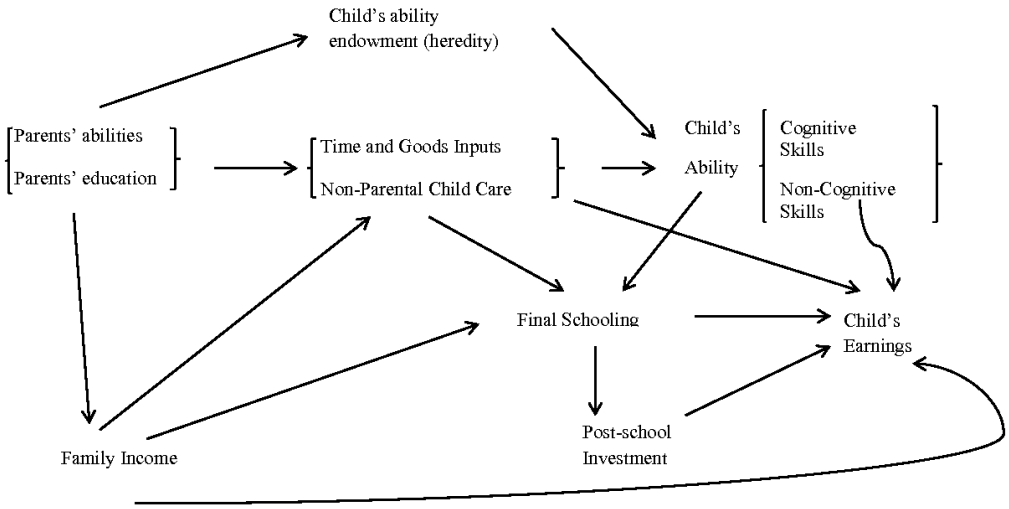
$$c^* \rightarrow \frac{U'_C}{U'_A} = \frac{A'_c}{p}$$
$$MRS_{CA} = \frac{A'_c}{p} \tag{1.7}$$

where MRS_{CA} is the marginal rate of substitution between consumption and child's ability. Condition (1.7) states that parents will invest in their child's human capital choosing non-parental child care up to the point where the marginal rate of substitution between consumption and child's ability is equal to the ratio between child care productivity and the price of child care. In this framework, the child care productivity A'_c represents the opportunity cost of choosing one more unit of consumption instead of investing in one hour more of child care.

Notice that the ratio on the right-hand side in (1.7), i.e., $\frac{A'_c}{p}$, is composed by variables that can be manipulated by the policy maker. In fact, a child care subsidization policy can decrease the price of child care p, while government regulation can improve the child care productivity perceived by the parents. A change in the price of child care or in the marginal productivity of the service can determine both an income or a substitution effect, depending on parental preferences over consumption and child's ability. If non-parental care represents an investment in child's human capital, an increase in its marginal productivity implies an higher opportunity cost of consumption. In case the substitution effect prevails, the demand for child care increases, yielding an increase in the child's human capital; instead, if the income effect prevails, parents may decide to invest less in child's human capital, decreasing their demand for external child care. This simple example shows how the interactions between child care policy and parental preferences can lead to different child care demand and different effects on child's ability. As suggested by Havnes and Mogstad (2010), for wealthier parents, that are supposed to be already investing in their child's human capital, the income effect would be prevailing and the demand for child care decreases. Instead, a policy increasing the child care productivity or decreasing its price can be effective for households with more stringent budget constraints for which it may enlarge their opportunity set; in this case, a substitution effect is more likely to prevail.

The utility function and the child's ability production function have been defined without specific functional forms. Even though the majority of this literature only considers linear production function (without taking into account the parents' utility maximization problem), it should be kept in mind that different functional forms assumptions can have different implications for the degree of substitutability between inputs and goods and, hence, for the investments decisions made by parents. Appendix 1.A further discusses this issue.

Figure 1.2
Non-parental child care inputs for child's development.



Notes. Figure adapted from Leibowitz (1974).

The model presented so far is static and assumes that parents decide their own investments during the child's first years of life. The structure of the model is still valid if one wants to test whether child care impacts last over time.

In order to understand the plausible mechanisms with which non-parental child care can influence child's development in the short, medium and long-run, consider a rearranged version of the framework proposed by Leibowitz (1974). In the original model, parents' abilities and education are transmitted to children genetically. They also jointly determine the level of family income and the quantity and quality of both time and goods inputs that parents devote to their children. Children's ability and the levels of parental income and home investments in time and goods determine the schooling attained by children and, through schooling, the level of postschool investment. All of these affect children's earnings and income. Figure 1.2 represents a version of this model, where non-parental child care is included among the investments made by parents and child's ability is composed by both cognitive and noncognitive skills. Both these types of skills are used in later developmental stages, both in education and in the labor market (Heckman et al., 2006).

The part of the figure on the left, where parents decide their investments (time and goods, as well as non-parental child care), reproduces the parents' decision making process previously described.

Notice that each investment choice has a multiplicative effect on subsequent (cognitive and noncognitive) skills that may affect long-term outcomes. In fact, parental investments during early childhood affect the level of child's ability immediately after the investments took place and during middle childhood. This short-run effect can be identified if a noisy measure of child's ability during early or middle childhood, e.g., test scores, is available. In the long-run, parental decisions can have an effect on both schooling and earnings. The effect on schooling can come either directly or through the effects of the investments on

ability in early and middle childhood. Instead, the final effect on earnings can be due to three channels: a direct effect on child's productivity when the child is an adult, induced by the investments themselves and long-lasting over time; an indirect effect that they have through schooling, since additional schooling determines higher wages; an indirect effect due to the impacts of the investments on middle childhood cognitive and noncognitive skills, so that these skills do not influence final schooling but have an effect on other personal traits and behavior that affect child's productivity in the labor market.

1.3. Empirical issues for the estimation of child care impacts

The majority of existing studies estimate a reduced-form version of the child's ability production function defined by (1.1), where also observable characteristics of parents and children are included. The estimation of the coefficient of interests in (1.1), i.e., for non-parental child care, is hampered by two main issues: (i) the difficulty to gather data on all relevant inputs for child development, and (ii) the selection problem due to the correlation of input choices with unobservables of both parents and children (Bernal and Keane, 2010).

Due to the absence of available data on all relevant inputs, the majority of studies does not estimate directly (1.1) but an approximation of that, given by the inclusion of proxy variables for omitted inputs.[6] Often this issue arises for the inputs τ and g that cannot be available or precisely measured in survey data. The information on the amount of time spent by the child with the parents has been substituted with the amount of working time of both parents, assuming a specific relationship between parents' child care and working time (Keane, 2010).[7] Only very recently information on the amount of time spent by the parents with the child has become available through the use of time use surveys, so that a direct measure for τ can be included in the estimation.[8] Concerning the information g, usually, it is used household income as a proxy, under the assumption that a constant proportion of income is devoted to the child. However, as pointed out in several empirical applications (Rosenzweig and Wolpin, 1995, Todd and Wolpin, 2003, Wolpin, 1997) the use of this proxy has implications for the interpretation of parameters, since it is related to the household decision rules.[9] However, it should be also recognized that a precise information on g is very difficult to gather. Even if explicitly asked to report their expenditure for the child, parents may underestimate their true spending, not considering common goods, such as food, housing, etc. (Del Boca et al., 2010).

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[6]Keane (2010) and Rosenzweig and Schultz (1983) define this production function *hybrid*.

[7]For instance, one may define parents' child care time as the difference between total time endowment and the time spent at work, i.e., $\tau = TT - h$.

[8]However, to the best of my knowledge, there are no studies evaluating the impact of non-parental child care using a true measure for the time spent by the child with the parents. Chapter 3 provides the first evidence on this issue, showing that using the actual measure of time instead of a proxy the results that are usually found in the literature are reversed. Instead, there are studies evaluating the impact of maternal and paternal time on child development, such as Del Boca, Flinn, and Wiswall (2010), Del Boca et al. (2012) and Hsin (2009).

[9]For instance, suppose that parents use a portion of their income to buy books and toys for their child; suppose also that once their income has increased, they choose to spend more money on books and to decrease their expenditure for toys. A plausible positive coefficient for income, in this case, does not say nothing about this allocation mechanism done by parents after that their income has changed: in fact, the positive income effect can be determined by the increase in the availability of books for the child, by the decrease in the availability of toys, or both.

The second issue refers to the endogeneity of the investment choices with respect to parents' and child's unobserved heterogeneity. Consider the following ability production function:

$$A = A(c, \tau, g, X, \mu) \tag{1.8}$$

where all inputs can be observed and the unique unobservable component is μ. The selection issue arises if non-parental child care choices are influenced by parents' or child's unobservables in a way that the researcher cannot control for. The component μ can be defined as:

$$\mu = \mu_p(t) + \mu_c(t) \tag{1.9}$$

where μ_c represents the child's unobservables component independent from parents' unobservables μ_p, and both of them can be varying over time. Estimating the child care impact from (1.8) without controlling for this selection may lead to an underestimation or an overestimation of the true effect; the direction of the bias depends not only on the selection but also on the different characteristics of the service and on the way they may affect child development.

Suppose that there is a positive selection of parents in external child care use, so that $corr(c, \mu_p) > 0$. This may happen if parents that provide a home environment that fosters child development are also more likely to select child care arrangements that do so as well. These parents may have an higher willingness to pay for the service and would be more likely to choose a center-based arrangement instead of an informal one. Estimating the coefficient for c without taking into account this selection would overestimate the true child care impact. However, the bias may be reversed if parents have a limited choice set and, for example, they can use only a service with an average quality lower than the quality time they can offer to their child at home. This happens in Felfe and Lalive (2010) that evaluate the impact of enrollment in public nurseries in Germany after the German reunification. The authors argue that when the availability of child care is scarce only highly-educated parents choose to use public nurseries that are also characterized by lower quality; their children do not benefit from child care attendance, since they would have received better inputs at home. Without controlling for this positive selection, in fact, the authors find a null impact of child care attendance on subsequent outcomes, implying an underestimation of the true effect. Allowing parents' and child's unobservables to be correlated would have had different implications: in this case, more skilled parents may be more likely to work and to use external child care but also to have more skilled children, regardless of the child care inputs they receive. Under these hypotheses, the true child care effect is overestimated, since those who are actually enrolled have also higher attainments. Finally, there may be a correlation between the parental decision and the child's unobservables, that the parents can (partially) observe. Suppose, for instance, that there is a positive selection of children enrolled in child care attendance: $corr(c, \mu_c) \geq 0$. This may happen if the mother prefers to send her extrovert child to (center-based) child care service, in order to improve his social and communicative skills. This choice reflects a reinforcing behavior of the mother, since she is investing more in her high-skilled child. Estimating the child care impact without controlling for this selection leads to an overestimation of the true effect. The bias would be even larger if the child care arrangement is of low quality, because the researcher can still conclude for a positive child care effect.

Hence, the bias depends not only on the selection of parents and children in individual child care use but also on the characteristics of the service offered by the market or by institutions. Also this point underlines the importance of public intervention, especially in the definition of homogeneous standards that, at least, can help understanding the baseline characteristics of the service.

Existing studies evaluating non-parental child care impacts adopt different strategies to handle these issues.

Some of them try to overcome the omitted variables bias arising because of missing data using very rich set of control variables. Some examples are Hansen and Hawkes (2009) and Goodman and Sianesi (2005) who evaluate the effect of several child care categories in U.K., or Leuven, Lindahl, Oosterbeek, and Webbink (2010) that assess the impact of early entry at school in the Netherlands. Basically, they estimate a child's ability production function of the form:

$$A = A(c, X, Z) \tag{1.10}$$

where Z is a vector of control variables and the component μ is not taken into account. Even with a large set of control variables, it is very likely that the selection arising in this framework does not depend on observables only, but also on unobservable characteristics. The control variable approach cannot be sufficient to take into account the selection of parents and children in individual child care attendance.

Other studies, mostly referred to the United States, use Mother (MFE) or Siblings (SFE) fixed effects that take into account time invariant unobserved heterogeneity at the household level. The unique example using this approach not referred to the U.S. is Berlinski, Galiani, and Manacorda (2008), who evaluate the impact of a child care policy in Uruguay. With this approach, the component μ_p in (1.9) cancels out under the assumptions that it is time-invariant and that parents' behavior does not depend on children's unobserved ability, i.e., $corr(\mu_c, c) = 0$. However, the "MFE estimates [...] could still be biased if there is child-specific unobserved heterogeneity or time-varying family-specific unobserved heterogeneity"(Blau, 1999a).

If it can be assumed that parents do not react to policy changes or instruments taking into account their child's ability, the unique approaches providing consistent estimates of the effects of interests are the Instrumental Variables (IV) and Differences-in-Differences (Diff-in-Diff) estimators. Both of them rely on the existence of an exogenous variation in child care use, due, for instance, to child care policies. The IV strategy has been used in several studies referred to European countries, even though it is very difficult to find enough powerful instrument in this framework. The main problem is that many variables at individual level that could be plausible instruments for child care use should also be included as determinants for child's development, so that the exogeneity assumption is very likely to fail. Other variables at aggregate level that have been used as instruments turned to be very weak.[10] This approach has been adopted by Datta Gupta and Simonsen

[10]In the literature estimating the impact of maternal employment on child development, James-Burdumy (2005) uses county labor force employed in services as instrument, but it turns to be extremely weak, yielding vary large standard errors and coefficients not statistically different from zero. James-Burdumy (2005) argues that her preferred specification is siblings fixed effect. In the literature evaluating the effect of external child care attendance, Datta Gupta and Simonsen (2011b) use IV but cannot reject the null that OLS estimates are equal to the IV estimates.

(2011a,b) and Felfe and Lalive (2010): the first studies refer to Denmark and use municipality features in child care provision as exogenous variation, while the second estimates the impact of public child care in Germany using, as exogenous variation, the large differentials in child care availability across German local areas. The Diff-in-Diff approach, instead, exploits the exogeneity of child care policies to evaluate their impact on child's subsequent attainments. Havnes and Mogstad (2010, 2011b) provide two excellent examples, evaluating the impacts of a preschool expansion policy implemented in Norway during the 1970s.

All the approaches summarized here mostly follow the EPF framework and provide estimates from a production function of the form defined by (1.8), or an approximation of that. However, when interpreting the results from these studies it should be kept in mind that each input (not only child care) is the result of a decision made by parents. As already stated, both the interpretation of the coefficients estimates and the identification of the effect strongly depends on the decision-making process of the parents. The interpretation of the results requires the knowledge of how these inputs are then chosen.

There is a final approach that may be applied to analyze the response of children's cognitive and noncognitive ability to parental child care decisions. This approach is based on the formulation and estimation of a behavioral model in which parents make sequential decisions on labor market participation and other inputs for child development, such as child care. In this framework, child's outcome is the result of a production process where inputs are optimally chosen by parents, that maximize their utility function subject to several constraints (as shown in the model presented in section 1.2.2). This approach is also based on the direct modeling of the sources of endogeneity and the estimation techniques allow for heterogeneity in tastes and constraints. There are several studies using this approach in the child development literature (Del Boca et al., 2010, Mroz, Liu, and Van der Klaauw, 2010), but only Bernal (2008) explicitly models maternal choice of work and child care use and estimates the impact of these choices on child's subsequent outcomes.[11] The studies using structural estimation stress the importance of taking into account the mechanisms underlying parents' choices, that turn to represent the inputs in the child cognitive ability production function. Among all the studies that will be presented in the following sections, only few of them provide a theoretical framework for the parents' decision making process that may help interpreting the results (Felfe and Lalive, 2010, Havnes and Mogstad, 2010).

1.4. Review of selected studies evaluating child care impacts

This section presents the results from selected studies evaluating the impacts of child care attendance or child care policies on several outcomes. Since the outcomes considered by the literature are multiple and range from early childhood cognitive to adolescence noncognitive to adulthood labor market outcomes, the following subsections present the results for each timing, i.e. early childhood vs middle childhood and adolescence vs adulthood. Early childhood outcomes refer to noisy measures of child's ability assessed immediately after the child care inputs have been implemented, up to the time when the child is

[11] Chapter 3 of this thesis estimates a model similar to the one presented in section 1.2.2, where the mother decides not only how much to work and how many hours of external child care to use but also how much time to dedicate to the child.

enrolled in grade 1 of primary school. Middle childhood and adolescence outcomes include those measured when the child is in the age range 7-16. Adulthood outcomes include the measures referred to education or labor market experience, as final education and wage, as measured when the child is an adult. The first two categories also distinguish between cognitive and noncognitive outcomes: it may help in understanding whether child care attendance can have different effects for specific developmental skills of the child.

1.4.1. Non-parental child care and early childhood cognitive and noncognitive outcomes. The studies evaluating the impact of child care or preschool on cognitive outcomes measured during early childhood are presented in tables 1.1 and 1.2. Tables 1.3 and 1.4 describes the studies evaluating short-term impacts on noncognitive outcomes. These outcomes are measured immediately after the input has been implemented, i.e., at kindergarten or primary school: the outcomes considered are school readiness and vocabulary tests as well as behavioral index or outcomes referred to habits at school. Measuring these effects is important, since it allows to test whether child care or preschool are effective in preparing the child for subsequent experience at school. However, it is not clear which type of service could have more influence on cognitive and noncognitive measures in the short-run. For instance, Hansen and Hawkes (2009) test the effectiveness of four child care categories (formal group, formal non-group, partner care and other informal care) on a vocabulary test and a school-readiness test, as well as on a noncognitive score, measuring the presence of behavioral problems. They find that formal group arrangements are more effective than other categories for the school readiness score and in decreasing the child's behavioral problems, while having attended a formal group child care has detrimental effect for the child's vocabulary abilities. Children who attended formal group child care get vocabulary score lower by 9 percent of a standard deviation than those who attended a formal non-group arrangement; however, those enrolled in formal group child care get a behavioral index lower than 12 percent of a standard deviation with respect to those cared for by their grandparents.

Felfe and Lalive (2010) provide, instead, estimates from the evaluation of the public child care system in Germany after the German reunification. The German case is very peculiar, since the private child care supply is almost absent and the government does not support child care policies, under the idea that child care should be a primary responsibility of mothers. As already stated in the previous section, the authors argue that the service can not be effective for child development if children come from wealthier households with more-educated parents. In fact, they find a very little impact when estimating their model using Ordinary Least Squares and higher effect when correcting for the selection using Instrumental Variables. They find positive effects of both having attended child care and the local supply of the service at childbirth on both cognitive and noncognitive skills: having attended child care increases the language skills index by 1.14 standard deviations and the noncognitive skills index by 0.9 standard deviations.

Comparing the results from Hansen and Hawkes (2009) and Felfe and Lalive (2010) gives an idea of the effectiveness of a privately provided center-based arrangement in U.K. with respect to the publicly provided one in Germany. In U.K., attending a center-based group facility has negative impacts on vocabulary scores, but also positive effects on behavioral outcomes. In Germany, instead, public child care has positive effects on both

Table 1.1
Selected studies evaluating child care impacts on early childhood cognitive outcomes. Description.

Study	Country	Data and Sample	Inputs/Policy	Outcomes	Timing
Hansen and Hawkes (2009)	U.K.	MCS (2001-02). Families with only one child, where the mother works when the child is 9 months old and her age at child birth is higher than 16. N=4,800.	4 child care categories: i) formal group; ii) formal non-group; iii) partner care; iv) other informal care or grandparents' care[a]	Vocabulary test, school-readiness test.	Inputs are measured when the child is 9 months old; outcomes are measured when the child is 3 years old.
Felfe and Lalive (2010)	Germany	GSOEP. N=762.	Having attended child care in 0-2 age range & local public child care supply at childbirth	Standardized index of language skills	Inputs are measured in 2002-2005 (the child is in age 0-2); outcomes are measured when the child is 24-47 months old.
Leuven et al. (2010)	The Netherlands	PRIMA Survey (1994-95, 1996-97,1998-99, 2000-01, 2002-03). Sample of pupils enrolled in grade 2 and never retained. Separate analysis for non-disadvantaged (N=28,942) and disadvantaged (N=23,893) children.	Early entry at primary school after the completion of the 4th birthday and before the 5th birthday.	Arithmetic and language test scores.	Inputs are measured when children are 4 years old; outcomes measured in grade 2 when the child is 6 years old.
Berlinski et al. (2009)	Argentina	ONEE (1995-1997) + CENSus 1991. Sample size changes with the outcomes. On average N=120,000.	Newly constructed slots of free public pre-primary school	Math and Spanish standardized test scores	Inputs measured in 1995-1997 when the child is 4/5 years old; outcomes measured when the child is in grade 3.
Gormley and Gayer (2005)	Oklahoma (us)	TPS (2001). Sample: children entering pre-k and kindergarten in 2001. N=2246	Universal pre-kindergarten	Cognitive and Language test scores.	Input measured when children are 4 years old; outcomes measured in kindergarten (5 years old).
Gormley (2008)	Oklahoma (us)	TPS (2006). Sample: hispanic children entering pre-k and kindergarten in 2006. Sample size changes according to the outcomes: on average N=550.	Universal pre-kindergarten	LW, Spelling and AP (WJ-R) test scores.	Input measured when children are 4 years old; outcomes measured in kindergarten (5 years old).

Abbrevations: MCS = Millennium Cohort Survey; GSOEP = German Socio-Economic Panel; PRIMA = Primary Education survey; ONEE = *Operativo Nacional de Evaluacion Educativa*; TPS = Tulsa Public Schools.
[a] Formal group = nurseries, creches; formal non-group = child-minders, nannies; partner care = child's father or mother's partner; other informal = relatives, friends.

Table 1.2
Selected studies evaluating child care impacts on early childhood cognitive outcomes. Results.

Study	Estimation technique	Coefficients
Hansen and Hawkes (2009)	OLS	Vocabulary score: formal non-group +0.089; partner care +0.108; grandparents care +0.193. School Readiness Score: formal non-group -0.122; partner care -0.129; grandparents care -0.108; other informal -0.193. Reference category formal group care.*
Felfe and Lalive (2010)	OLS, IV and RF. Instrument: local child care supply at childbirth.	OLS (effect of having used child care): +0.18 on language skills. RF (child care supply impact): +0.0118 on language skills. IV: +1.141.*
Leuven et al. (2010)	OLS	Effect of one more month of schooling on disadvantaged +0.061 on language score and +0.06 on arithmetic score.
Berlinski et al. (2009)	OLS	Effect of one more place at pre-primary school on Math score +4.694 and on Spanish score +4.761.
Gormley and Gayer (2005)	RDD. Treatment: having attended Tulsa pre-k in 2000; Controls: 1) not having attended Tulsa pre-k in 2000; 2) waiting for pre-kindergarten admittance in 2001	Treated children have cognitive score +0.756 and language score +0.817.
Gormley (2008)	RDD. Treatment: having attended Tulsa pre-k in 2005; Controls: 1) not having attended Tulsa pre-k in 2005; 2) waiting for pre-kindergarten admittance in 2006	Treated children have LW score +2.471, AP +1.928, Spelling test score +1.360.

Abbrevations: OLS = Ordinary Least Squares, IV = Instrumental Variables, RF = Reduced Form, RDD = Regression Discontinuity Design.
Notes. Estimates reported in this table represent the raw coefficients presented in each study. * indicates that the study uses a standardized dependent variable, so that coefficients can be interpreted in terms of a standard deviation. + indicates that the dependent variable is log-transformed and that coefficients multiplied by 100 can be interpreted as percentage change.

language and noncognitive skills, but the magnitude of the impact is greater for language skills. However, both these studies pose some doubts on their ability of taking into account observed and unobserved heterogeneity of mothers' preferences for child care use. Hansen and Hawkes (2009) partially control for the heterogeneity in mothers' preferences keeping only working mothers in the sample; even though this strategy seems to increase the homogeneity of the sample, it is very likely to provide an upper bound of the child care demand and the coefficients estimates should be interpreted accordingly. Instead, Felfe and Lalive (2010) use an Instrumental Variables approach to take into account the selection of parents in individual child care use, exploiting local (cross-sectional and temporal) differences in child care supply as exogenous variation. Although their explanation of the selection process driving the results can be reasonable, the high standard errors of the IV estimates pose some doubts on the relevance of the instrument.

Berlinski et al. (2009) evaluate the impact of a policy expanding free and public pre-primary school places, implemented during late 1990s in Argentina. Their estimates lay

Table 1.3
Selected studies evaluating child care impacts on early childhood noncognitive outcomes. Description.

Study	Country	Data and Sample	Inputs/Policy	Outcomes	Timing
Hansen and Hawkes (2009)	U.K.	MCS (2001-02). Families with only one child, where the mother works when the child is 9 months old and her age at child birth is higher than 16. N=4,800.	4 child care categories: i) formal group; ii) formal non-group; iii) partner care; iv) other informal care or grandparents' care[a]	SDQ[b] behavioral test.	Inputs are measured when the child is 9 months old; outcomes are measured when the child is 3 years old.
Felfe and Lalive (2010)	Germany	GSOEP. N=762.	Having attended child care in 0-2 age range & local public child care supply at childbirth	Standardized indexes for: i) independence skills; ii) social skills; iii) behavior; iv) personality; v) motor skills.	Inputs are measured in 2002-2005 (the child is in age 0-2); outcomes are measured when the child is 24-47 months old.
Gormley and Gayer (2005)	Oklahoma (us)	TPS (2001). Sample: children entering pre-k and kindergarten in 2001. N=2246	Universal pre-kindergarten	Motor skills test	Input measured when children are 4 years old; outcomes measured in kindergarten (5 years old).

Abbreviations: MCS = Millennium Cohort Survey; GSOEP = German Socio-Economic Panel; TPS = Tulsa Public Schools.
[a] Formal group = nurseries, creches; formal non-group = child-minders, nannies; partner care = child's father or mother's partner; other informal = relatives, friends.
[b] SDQ = Strength and Difficulties Questionnaire. Higher score indicates more behavioral problems.

in between the U.K. and the German cases. In fact, the effect of one more place at pre-primary school on Math score is equal to +4.694, while for Spanish score it is equal to +4.761. Standardizing these coefficients, it yields that one more place at pre-primary school increases the Math and the Spanish scores by 0.24 and 0.23 standard deviations, respectively.[12]

Finally, two study refer to a public intervention aimed to offer universal pre-kindergarten in Oklahoma (U.S.). Differently from the majority of studies in the U.S., they consider a public preschool policy. Both Gormley and Gayer (2005) and Gormley (2008) evaluate the Tulsa Pre-Kindergarten program, started in 1998, using a Regression Discontinuity approach and exploiting the age cutoff for children to be enrolled in the program. Gormley and Gayer (2005) find that having attended high-quality preschool increases children's cognitive, language and motor skills scores by, respectively, 0.76, 0.82 and 0.41 points. Moreover, full-day treatment has stronger effects on the outcomes for black children. Gormley (2008) evaluates the same policy five years later only on Hispanic children

[12]As reported in Berlinski et al. (2009, table 4), the standard deviations of the score measures are, respectively, 19.70 for Math and 20.41 for Spanish. The standardized effects are then: 4.694/19.70=0.24 for Math and 4.761/20.41=0.23 for Spanish.

Table 1.4
Selected studies evaluating child care impacts on early childhood noncognitive outcomes. Results.

Study	Estimation technique	Coefficients
Hansen and Hawkes (2009)	OLS	Grandparents care with respect to formal group care +0.121.[a*]
Felfe and Lalive (2010)	OLS, IV and RF. Instrument: local child care supply at childbirth.	OLS (effect of having used child care): +0.203 on noncognitive skills, +0.176 on independence, +0.325 on social skills, +0.195 on motor skills. RF (child care supply impact): +0.0087 on noncognitive skills, +0.0078 on independence, +0.0105 on social skills, +0.00765 on behavior, +0.0071 on motor skills. IV: +0.901 on noncognitive skills, +0.807 on independence, +1.086 on social skills, +0.792 on behavior, +0.742 on motor skills.[*]
Gormley and Gayer (2005)	RDD. Treatment: having attended Tulsa pre-k in 2000; Controls: 1) not having attended Tulsa pre-k in 2000; 2) waiting for pre-kindergarten admittance in 2001	Treated children have motor skills index +0.413.

Abbreviations: OLS = Ordinary Least Squares, IV = Instrumental Variables, RF = Reduced Form, RDD = Regression Discontinuity Design.
Notes. Estimates reported in this table represent the raw coefficients presented in each study. * indicates that the study uses a standardized dependent variable, so that coefficients can be interpreted in terms of a standard deviation. + indicates that the dependent variable is log-transformed and that coefficients multiplied by 100 can be interpreted as percentage change.
[a] Since an higher outcome means more behavioral problems, a positive coefficient implies a detrimental effect.

and finds positive and statistically significant effects on both the LW and the AP test scores. Furthermore, he finds stronger effects for children whose parents were born in Mexico and for Spanish speaking children, who may need more help to compensate their linguistic disadvantage.[13]

From these studies, it is possible to draw some conclusions concerning the short-term impacts of non-parental child care. The study referred to the U.K., comparing the effect of different child care categories, confirms that the distinction between center-based and informal services plays a significant role. All other studies evaluating specific child care policies, although referring to very different countries, consistently find positive effects of formal child care or preschool on both cognitive and noncognitive outcomes.

1.4.2. Non-parental child care impacts on middle-childhood and adolescence outcomes. There are several studies evaluating the impacts of child care attendance on medium-term outcomes, measured when children have between 7 and 11 years of age. The majority of them considers cognitive attainments, assessed at school, but there are also examples of noncognitive outcomes, such as scores and indexes based on the factorization of several variables providing information on the acquisition of diverse

[13]It is interesting to compare these results with those provided in other studies evaluating the impact of any non-maternal child care arrangement on subsequent child's outcomes, i.e., the treatment is to having used any kind of external child care. For instance, Bernal (2008) and Bernal and Keane (2011, 2010) find that maternal employment and external child care before kindergarten have strongly negative effects on children's test scores ranging between 1.8 and 3 percent in absolute value.

skills. Table 1.5 describes the main features of studies considering cognitive outcomes, while table 1.6 presents their results; instead tables 1.7 and 1.8 show the main findings concerning noncognitive medium-term outcomes.

Measuring the effect of child care and preschool policies in the medium run is crucial to see whether the positive impacts of these policies remain or, instead, dissipate over time. For instance, for the U.S., Currie and Thomas (1995, 1999) evaluate the effect of having attended the program Head Start on children aged more than 6. They still find a positive impact of the program on both PPVT test score and the probability of not being retained on white and Hispanic children, but for black these effects dissipate over time. The authors explain this finding arguing that black children are less likely to receive high-quality investments in human capital at primary and secondary schools, so that the positive effect of the program is more likely to vanish. These results also suggest that effective investments in children's human capital should be followed by subsequent intervention of the same quality (Almond and Currie, 2011).

In the European literature, apart from Goodman and Sianesi (2005), all the studies evaluate the impact of a child care or preschool policy. Datta Gupta and Simonsen (2011a,b) consider the high-quality preschool service in Denmark and find that having attended preschool (with respect to family day care) increases the language score of children at age 7 by 8 percent of a standard deviation and decreases their behavioral problem index by 0.42 points; instead, they do not find any effect on noncognitive outcomes at 11. Felfe and Lalive (2010) consider a child care policy in Germany and find that having attended child care in the first years of life increases grades at school by 1.4 percent of a standard deviation and noncognitive skills by 1.68 standard deviations. Comparing the estimates from Denmark and Germany, it seems that having attended the high-quality and strictly regulated preschool in Denmark has stronger effect than the child care policy in Germany. However, the stronger effect of the Danish case may also be due to timing issues, since that study refers to a preschool policy, while Felfe and Lalive (2010) evaluate a policy for children aged 0-2: the longer distance between the time when the input is implemented and the one when the outcome is measured can also determine the smaller effect that is found.[14]

The positive implications for cognitive outcomes in the medium-run are fairly consistent across countries and methodologies. Dumas and Lefranc (2010) evaluate a preschool expansion implemented in France during the 1960s and the 1970s and estimate both the effects of the age of entry at preschool and the effect of preschool duration. They find that entry at 2 years (instead of at 3) increases test scores at grade 6 and the probability of graduation at high school; moreover, staying at preschool 3 years (instead of 1) decreases the number of grade repetitions at age 11 and 16. Berlinski et al. (2008) find that the positive child care impact increases as the child ages, instead of dissipating over time: having attended at least one year of preschool in Uruguay increases both the probability of attending school and the number of years of education; further, the coefficients are higher for 15 years old children than for children aged 7. Finally, for the U.S., Fitzpatrick

[14]Chapter 2 presents a study on the child care policy in Italy, using, as outcome variables, school grades on Language and Math for 2nd graders at primary school. Results are in line with the ones found by Felfe and Lalive (2010).

Table 1.5

Selected studies evaluating child care impacts on middle childhood and adolescence cognitive outcomes. Description.

Study	Country	Data and Sample	Inputs/Policy	Outcomes	Timing
Datta Gupta and Simonsen (2011b)	Denmark	DALSC & DAR. Sample size changes according to the outcome, on average N=3,000.	Enrollment in publicly provided child care (preschool or family day care) vs home care.[a]	CHIPS[c] score, dummy for having repeated a grade, self-evaluated school performances.[d]	Inputs measured at age 3-6; outcomes measured at 11.
Dumas and Lefranc (2010)	France	DEPP & FQP. Sample size changes according to the dataset: DEPP on average N=20,000, FQP on average N=8,000.	Age of entry at preschool (3, 4 or 5 years old) from DEPP, duration of preschool (1, 2 or 3 years) from FQP.	Outcomes from DEPP data: number of grade repetitions at 11 and at 16, test scores in 6th grade, dummy for high school graduation; outcomes from FQP data: number of grade repetitions at 11 and at 16, dummy for high school graduation.	Inputs measured at age 3-6; outcomes measured at ages 11 and 16.
Felfe and Lalive (2010)	Germany	GCP. N=686.	Having attended child care in age 0-2 & local child care supply at childbirth	School grade.[e]	Inputs measured at age 0-2 for children born in 1996-1997; outcomes measured between 5-10 years.
Goodman and Sianesi (2005)	U.K.	NCDS. N=12,172.	Dummy for having attended any pre-compulsory education[f]; dummy for having attended preschool vs staying home or starting primary school earlier.	Overall cognitive development score[g] at 7, 11 and 16; dummy for having needed special education at 7.	Inputs measured when the child is 4 years old (born in 1958); outcomes measured when the child is 7 (1965), 11 (1969) and 16 (1974) years old.
Berlinski et al. (2008)	Uruguay	ECH (2001-2005). Sample: individuals aged 7-15 living in 2 parents households and children of the household head. N=23,402.	Having attended at least one year of preschool.	Current school attendance and years of schooling completed.	Inputs measured in the age 3-6; outcomes measured in the age 7-15.
Fitzpatrick (2008)	Georgia (us)	NAEP (1993-2004). Sample size changes according to the outcomes. On average N=600,000.	Universal pre-kindergarten program for all 4 years old children starting from 1995.	Reading and Math test scores, dummy for being on grade.	Policy intervenes when children are 4 years old; outcomes measured when children are in grade 4.

Abbreviations: DALSC = Danish Longitudinal Survey of Children; DAR = Danish Administrative Registers; DEPP = French Ministry of Education Panel; FQP = Education, Training and Occupation survey; NCDS = National Child Development Study; ECH = *Encuesta Continua de Hogares*; NAEP = State National Assessment of Educational Progress.

[a] Preschool = center based care. Family Day Care = care provided in private homes. Home care = care provided by parents.

[b] SDQ = Strength and Difficulties Questionnaire. Higher score indicates more behavioral problems.

[c] CHIPS = Children's Problem Solving Test with non-math logic questions.

[d] Self-evaluated school performances are constructed as dummy variables indicating whether the child has excellent academic performances, likes school very much, is good at most things at school, is good in Math, is good in Danish.

[e] Final grade attained in the most recent grade transcript as reported by the mother.

[f] Pre-compulsory education includes any form of education (preschool or early entry) before the compulsory starting age of 5.

[g] Average (standardized) score over Math and Reading test scores for any age.

Table 1.6

Selected studies evaluating child care impacts on middle childhood and adolescence cognitive outcomes. Results.

Study	**Estimation technique**	**Coefficients**
Datta Gupta and Simonsen (2011b)	OLS and IV. Instrument: dummy for living in a municipality providing universal access to preschool (GAPS).[a]	OLS: effect of preschool (vs family day care) +0.414 on language test. IV: effect of preschool (vs family day care) n.s. for all outcomes but +0.107 for the dummy indicating whether the child likes the school very much.
Dumas and Lefranc (2010)	OLS with school/birth-department fixed effects	No. of repetitions at 11: entry at 2 +0.0938, entry at 4 +0.0843; test score at 6th grade: entry at 2 +0.0672, entry at 4 -0.105; no. of repetitions at 16: -0.142, entry at 4 +0.106; entry at 2 has positive and significant impact on the probability of graduation; ref. cat. entry at school at 3 years old. No. of repetitions at 11: staying at school 2 years -0.036, staying in preschool 3 years -0.068; no. of repetitions at 16: staying in preschool 2 years -0.066, staying in preschool 3 years -0.098; ref. cat. 1 year of preschool.
Felfe and Lalive (2010)	OLS, IV and RF. Instrument: local child care supply at childbirth.	OLS (effect of having used child care): -0.193 on grades (core courses), -0.179 on grades (liberal courses). RF (child care supply impact): +0.0142 on grades (core courses), +0.0157 on grades (liberal courses).*
Goodman and Sianesi (2005)	OLS	Effect of any pre-compulsory education: +0.09 on cognitive development index at 7, +0.067 on cognitive development index at 11, +0.048 on cognitive development score at 16. Effect of preschool: +0.053 on cognitive development score at 7, +0.036 on cognitive development score at 11.*
Berlinski et al. (2008)	MFE	Effect of having attended at least 1 year of preschool varies with child's age at the time of the interview (7-15). Effect on the probability to attend school: +0.043 when children are 7 years old, +0.274 when children are 15 years old. Effect on years of schooling: -0.341 when children are 7 years old, +0.788 when children are 15 years old.
Fitzpatrick (2008)	Diff-in-Diff	Effect of the treatment only on Math score: +0.017.*

Abbreviations: OLS = Ordinary Least Squares, IV = Instrumental Variables, RF = Reduced Form, MFE = Mother Fixed Effects.

Notes. Estimates reported in this table represent the raw coefficients presented in each study. * indicates that the study uses a standardized dependent variable, so that coefficients can be interpreted in terms of a standard deviation. + indicates that the dependent variable is log-transformed and that coefficients multiplied by 100 can be interpreted as percentage change.

[a] GAPS = Guaranteed Access to Pre-School.

Table 1.7
Selected studies evaluating child care impacts on middle childhood and adolescence noncognitive outcomes. Description.

Study	Country	Data and Sample	Inputs/Policy	Outcomes	Timing
Datta Gupta and Simonsen (2011a)	Denmark	DALSC & DAR. N=4,343.	Enrollment in publicly provided child care (preschool or family day care) vs home care.[a]	SDQ[b] behavioral test.	Inputs measured at age 3-6; outcomes measured at age 7.
Datta Gupta and Simonsen (2011b)	Denmark	DALSC & DAR. Sample size changes according to the outcome, on average N=3,000.	Enrollment in publicly provided child care (preschool or family day care) vs home care.[a]	SDQ[b] behavioral test at age 11, dummy for smoking, dummy for drinking, dummy for vandal behavior.	Inputs measured at age 3-6; outcomes measured at age 11.
Felfe and Lalive (2010)	Germany	GCP. N=686.	Having attended child care in age 0-2 & local child care supply at childbirth	Standardized indexes for: i) independence skills; ii) social skills; iii) behavior; iv) personality; v) motor skills.	Inputs measured at age 0-2 for children born in 1996-1997; outcomes measured at 5-10 years.
Goodman and Sianesi (2005)	U.K.	NCDS. N=12,172.	Dummy for having attended any pre-compulsory education[c]; dummy for having attended preschool vs staying home or starting primary school earlier.	Overall social development at 7 and 11; proportion of very bad self-control skills at 7.[d]	Inputs measured at 4 years old for the cohort of children born in the first week of March 1958; outcomes measured in 1965, 1969 and 1974 (when the child is 7-11 years old).

Abbreviations: DALSC = Danish Longitudinal Survey of Children; DAR = Danish Administrative Registers; GCP = German Child Panel; NCDS = National Child Development Study; ECH = *Encuesta Continua de Hogares*; NAEP = State National Assessment of Educational Progress.
[a] Preschool = center based care. Family Day Care = care provided in private homes. Home care = care provided by parents.
[b] SDQ = Strength and Difficulties Questionnaire. Higher score indicates more behavioral problems.
[c] Pre-compulsory education includes any form of education (preschool or early entry) before the compulsory starting age of 5.
[d] Proportion of very bad self-control skills out of: destructive, irritable, difficulty concentrating, upset by many situations, miserable, etc. The higher the proportion, the worse the outcome.

(2008) finds a positive effect of having attended the Georgia pre-kindergarten program on Math score.

Hence, child care and preschool policies, both in European and in Latin American countries, seem to have positive effects also on outcomes measured some years later their implementation. This result is in contrast with the Currie and Thomas' findings concerning the program Head Start and black children. A plausible explanation for this difference can be the institutional contexts characterizing these countries, not only in relation to the child care policy, but also to subsequent policies investing in children's human capital (e.g., primary and secondary school).

Table 1.8
Selected studies evaluating child care impacts on middle childhood and adolescence noncognitive outcomes. Results.

Study	Estimation technique	Coefficients
Datta Gupta and Simonsen (2011a)	OLS and IV. Instrument: dummy for living in a municipality providing universal access to preschool (GAPS).[a]	OLS: children in family day care (vs home care) +1.808; children in preschool (vs family day care) -0.421.[b] IV: effect of preschool (vs family day care) n.s.
Datta Gupta and Simonsen (2011b)	OLS and IV. Instrument: dummy for living in a municipality providing universal access to preschool (GAPS).[a]	OLS and IV: effect of preschool (vs family day care) n.s.
Felfe and Lalive (2010)	OLS, IV and RF. Instrument: local child care supply at childbirth.	RF (child care supply impact): +0.0137 on noncognitive skills, +0.0129 on independence, +0.0105 on personality. IV: +1.687 on noncognitive skills, +1.592 on independence.[*]
Goodman and Sianesi (2005)	OLS	Effect of any pre-compulsory education: -0.053 on social development index at 7, +0.008 on very bad self-control skills at 7,[b] +0.006 on very bad self-control skills at 11.[b] Effect of preschool: +0.014 on very bad self-control skills at 7, +0.01 on very bad self-control skills at 11.[b*]

Abbreviations: OLS = Ordinary Least Squares, IV = Instrumental Variables, RF = Reduced Form, MFE = Mother Fixed Effects.
Notes. Estimates reported in this table represent the raw coefficients presented in each study. [*] indicates that the study uses a standardized dependent variable, so that coefficients can be interpreted in terms of a standard deviation. [+] indicates that the dependent variable is log-transformed and that coefficients multiplied by 100 can be interpreted as percentage change.
[a] GAPS = Guaranteed Access to Pre-School.
[b] Since an higher outcome means more behavioral problems, a positive coefficient implies a detrimental effect.

1.4.3. Long-term adult outcomes of early non-parental child care. In the U.S. literature, there exist several studies evaluating the long-run impacts of child care programs targeted toward disadvantaged households and children. For instance, Currie, Garces, and Thomas (2002) find that having attended the program Head Start increases the probability that the child attends high school and college and increases adult earnings by 19 percent. Barnett and Masse (2002) assess the impacts of the Carolina Abecedarian Program on children at 21 years of age and find positive effects on the probability of attending college, while the impacts on criminal behavior and grade retention are negative. Heckman, Moon, Pinto, Savelyev, and Yavitz (2010) estimate a rate of return of the Perry Pre-School program ranging between 7 and 8 percent.[15]

Recently, there have been several studies assessing the long-run effects of child care policies implemented in European countries during the 1960s and 1970s. They are summarized in table 1.9, while their main findings are reported in table 1.10.

Dumas and Lefranc (2010) report the effects of preschool duration in France on monthly wage, while Goodman and Sianesi (2005) estimate the impact of having attended

[15]See Cunha et al. (2006) for additional details.

Table 1.9
Selected studies evaluating child care impacts on adulthood outcomes. Description.

Study	Country	Data and Sample	Inputs/Policy	Outcomes	Timing
Dumas and Lefranc (2010)	France	FQP. Sample of birth cohorts 1950-1973. N=5,843.	Duration of preschool (1, 2 or 3 years)	Monthly wage	Inputs measured when children are 3-6; outcome measured in 1993 when children are 20-43
Goodman and Sianesi (2005)	U.K.	NCDS. N=12,172.	Dummy for having attended any pre-compulsory education[a]; dummy for having attended preschool vs staying home or starting primary school earlier.	Dummy for having obtained any qualification above Level 1 by age 42, dummy for having obtained any qualification at Level 4 or 5 (higher education) by age 42, employment status and hourly wage at 33 and 42.	Inputs measured at 4 years old for the cohort of children born in the first week of March 1958; outcomes measured in 1991 and 2000 when children are aged 33-42 years.
Havnes and Mogstad (2011b)	Norway	Statistics Norway (1967-2006). Sample of children born in 1967-1976, living in Norway in 2006 and whose mother was married at the time of the kindergarten reform (1975). N=499,026.	Impact of a kindergarten reform that increased formal preschool during the '70s.	Outcomes: years of education, having attended some college, being high-school drop-out, being low, average, high or top earner,[b] being on welfare,[c].	Input measured when children were at kindergarten age; outcomes measured in 2006 (aged between 30-39 years).
Havnes and Mogstad (2010)	Norway	Statistics Norway (1967-2006). Sample of children born in 1967-1976, living in Norway in 2006 and whose mother was married at the time of the kindergarten reform (1975). N=498,956.	Impact of a kindergarten reform that increased formal preschool during the '70s.	Adult annual earnings (Million NOK) of children exposed to the reform.	Input measured when children were at kindergarten age; outcomes measured in 2006 (aged between 30-39 years).

Abbreviations: FQP = Education, Training and Occupation survey; NCDS = National Child Development Study.
[a] Pre-compulsory education includes any form of education (preschool or early entry at primary school) before the compulsory starting age of 5.
[b] Low earner = earnings lower than 2 basic amounts; average earner = earnings equal at least to 4 basic amounts; high earner = earnings equal at least to 8 basic amounts; top earner = earnings equal at least to 12 basic amounts. 1 basic amount = 10,500$.
[c] Being on welfare = receiving more than 1 basic amount as public cash transfer.

preschool in U.K. on educational attainments and hourly wage at 33 and 42 years. Results from these studies are very similar, confirming that a long-lasting positive effect of preschool attendance is consistent across countries. The former study finds that staying

Table 1.10
Selected studies evaluating child care impacts on adulthood outcomes. Results.

Study	Estimation technique	Coefficients
Dumas and Lefranc (2010)	OLS with school/birth-department fixed effects	Staying in preschool 2 years increases monthly wage by +0.0298, staying in preschool 3 years increases wage by +0.046.$^{+}$ Ref. cat.: staying in preschool 1 year.
Goodman and Sianesi (2005)	OLS	Effect of any pre-compulsory education: +0.018 on probability of employment at 33, -0.038 on probability of needing special education, +0.029 on probability of any qualification above level 1 at 33; +0.027 on wages at 33, +0.022 on wages at 42.$^{+}$ Effect of preschool: +0.027 on wages at 33, +0.036 on wages at 42.$^{+}$
Havnes and Mogstad (2011b)	Diff-in-Diff	+0.3523 on years of education, +0.0685 on the probability of attending college, -0.0584 on the probability of being high-school drop-out, -0.0359 on the probability of being low earner, +0.0514 on the probability of being average earner, -0.0337 on the probability of being high earner, -0.0511 on the probability of being on welfare.
Havnes and Mogstad (2010)	Non-Linear Diff-in-Diff	Effect of the policy on the mean n.s.. Effect of the policy on the income distribution: +0.032 on the 10th percentile, +0.055 on the 20th percentile, 0 on the 68th percentile, -0.038 on the 90th percentile.^{a}

Abbreviations: OLS = Ordinary Least Squares.
Notes. Estimates reported in this table represent the raw coefficients presented in each study. * indicates that the study uses a standardized dependent variable, so that coefficients can be interpreted in terms of a standard deviation. $^{+}$ indicates that the dependent variable is log-transformed and that coefficients multiplied by 100 can be interpreted as percentage change.
^{a} The dependent variable is the probability that post-reform earnings are higher than a certain percentile in the pre-reform earnings distribution. Reported coefficients represent Treatment on the Treated (TT) effects.

in preschool 3 years (instead of 1) increases monthly wage by 4.6 percent, while the latter finds that having attended preschool increases hourly wage by 2.7 percent at age 33 and by 3.6 percent at age 42. To see the magnitude of these effects, consider an adult with an hourly gross wage of 13 Euro, working 8 hours a day for 20 days in a month. According to the Dumas and Lefranc (2010) paper, the change in the monthly wage due to 3-years preschool attendance, other things being equal, is equivalent to almost 95 Euro;[16] instead, using the estimates from Goodman and Sianesi (2005), the change in the hourly gross wage at 42 due to preschool attendance is equivalent to 75 Euro.[17] The magnitude of these impacts is substantial. The fact that the effects is higher in France than in U.K. may be due to the different characteristics of the service, since preschool could be more strictly regulated in France than the in U.K.. However, it can also depend on the definition of the variables of interests in the two studies: in Dumas and Lefranc the regressor of

[16]The monthly gross wage is given by $13 \times 8 \times 20 = 2,080$. 4.6 percent of 2,080 is equivalent to 95.68 Euro.
[17]3.6 percent of 13 Euro is equivalent to 0.468 Euro. Measuring this change on a monthly basis, it yields $74.88 = 0.468 \times 8 \times 20$.

interests is entry age at preschool and the impact reported above refers to children that started preschool at 2 years of age instead of 5; hence, the treatment is clearly to have attended 3 years of preschool. Instead, in the Goodman and Sianesi paper, the treatment is a more generic preschool attendance, that could be shorter than 3 years.

Dumas and Lefranc (2010) provide a very interesting result: the positive effect on wage remains either controlling or not controlling for final education; it seems that preschool has a *direct* effect on earnings in addition to the effect that it has through education. This issue has been raised by other studies in this literature (Chetty, Friedman, Hilger, Saez, Schanzenbach, and Yagan, 2011); a possible explanation is that preschool favors the acquisition of noncognitive skills that are rewarded in the labor market, such as self-esteem and socialization. This mechanism has been already presented in figure 1.2 that shows how the parental decisions and the child's noncognitive skills developed during early childhood affect directly child's earnings in addition to the effect that they have through final schooling. As suggested by Cunha et al. (2006), even when early childhood intervention do not boost cognitive skills, it improves the noncognitive ones, with substantial effects on labor market and behavioral outcomes.

Finally, Havnes and Mogstad (2010, 2011b) estimate the long-term effects of a policy implemented in Norway during the 1970s, aimed to increase formal preschool attendance. Havnes and Mogstad (2011b) evaluate the impact on several outcomes referred to both the educational perspectives of children when adults and to their labor market experience: years of education, having attended some years of college, being high-school drop-out, earnings and being on welfare. Their results have the expected signs, confirming that the policy[18] has increased years of education and the probability to attend college and decreased the probability of being on welfare and being high-school dropout. However they find negative effects of the policy on the probability of being low and high earners, while the effect is positive on the probability to be average earner. These heterogeneous impacts are further investigated in Havnes and Mogstad (2010), that evaluate the impact of the policy on the entire earnings distribution. They find that the policy has been more effective for children in the lower and median part of the distribution, up to the 70th percentile, while it has been detrimental for those in the higher part of the distribution, that would have got higher earnings without the policy implementation. According to the theoretical framework provided in section 1.2.2, these children did not benefit from the policy since their parents were already investing in their human capital. Instead, the policy can be effective for those with a low initial level of (investments in) human capital: for those people the policy has enlarged their parents' opportunities frontier, since they could choose among more options to invest in the human capital of their children.

1.5. Conclusions

This survey provides an analysis of existing studies evaluating non-parental child care impacts, posing particular attention to contexts different from the U.S. and focusing more on child care policies rather than on heterogenous child care services. The aim of the

[18]Actually, the authors do not observe whether a child attended preschool or not, so that their estimates should be considered as Intention to Treat (ITT) coefficients. Indeed, they compute the Treatment on the Treated (TT) effects dividing the ITT coefficients by the increase in child care coverage following the reform in the treatment group relative to the comparison group. In the tables, only TT estimates are reported.

survey is to show the importance of institutions in modeling the opportunity sets available to parents when they make their non-parental child care decisions.

Existing literature on the impacts of non-parental child care on child's outcomes do not provide homogeneous results. The differences can be mostly explained by the diverse institutional context considered and by the characteristics of the service that is analyzed. In fact, when similar child care policies (or formal well-regulated arrangements) are considered, these differences cancel out and all the studies provide evidence of positive child care impacts.

All the studies evaluating the impacts of non-parental child care in the short- and medium-run find positive effects on cognitive outcomes, while the implications for the noncognitive ones are mixed. As pointed out by Cunha et al. (2006), much of the effectiveness of early childhood interventions comes from boosting cognitive and noncognitive skills, that can have substantial effects on schooling and labor market outcomes during adulthood. Positive effects of preschool attendance and preschool policies on adult earnings are found in both U.K., France and Norway, and the magnitude of the impacts is similar across countries. According to the theoretical framework proposed in section 1.2.2, however, not all children may equally benefit from a policy increasing child care or preschool availability. In fact, the final outcome depends on the interaction between the policy and parents' preferences and budget constraint. While positive long-run effects of child care policies have been found, on average, by Goodman and Sianesi (2005) for U.K. and Dumas and Lefranc (2010) for France, Havnes and Mogstad (2010) report a positive impact of a preschool policy implemented in Norway only for children in the lower part of the earnings distribution, while children in the upper part of the distribution did not benefit from the policy. This result also confirms that child care and preschool intervention can be more effective for children living in disadvantaged backgrounds, because it can provide better educational inputs than those they would have received at home.

The studies presented in this survey have two main limitations. First of all, the majority of them may fail in taking into account the endogeneity sources characterizing this framework, so that the coefficients estimates can be biased. Second, very few of them provide a theoretical framework that may help in understanding the results and no one takes into account that the inputs are actually chosen by parents: only the child's ability production function is estimated. This issue prevents also from understanding some of the mechanisms with which non-parental child care affects child's development.

Further research can help in identifying the mechanisms through which preschool and child care attendance have an impact on child development, especially in the long-run. For instance, further should be investigated on the relationship between the child care input and the development of noncognitive skills, that may have a direct effect on earnings in addition to the one through education.

1.A. Functional form assumptions and substitutability patterns

Without loss of generality, the utility function and the child's ability production function proposed in section 1.2.2 have been defined without specific functional forms. However, different functional form assumptions may have implications for the degree of substitutability between goods and inputs.

As suggested by Almond and Currie (2011), the most flexible specification for both the child's ability production function and the parents' utility function is the CES functional form, since it allows to identify both the parameters of the elasticity of substitution between inputs and the one between goods. Suppose, for instance, that child's ability depends only on external child care and time shared with the parents, and that parents care about consumption and child's ability. Thus, equations (1.2) and (1.5) can be written as:

$$U = [\alpha_1 C^{\rho} + \alpha_2 A^{\rho}]^{\frac{1}{\rho}} \tag{1.A.1}$$

$$A = [\gamma \tau^{\phi} + (1-\gamma) c^{\phi}]^{\frac{1}{\phi}} \tag{1.A.2}$$

where $-\infty < \rho \leq 1$ and $-\infty < \phi \leq 1$.

The elasticity of substitution between inputs from equation (1.A.2) can be derived as follows.

The marginal productivity of each input is defined as:

$$\frac{\partial A}{\partial \tau} = [\gamma \tau^{\phi} + (1-\gamma) c^{\phi}]^{\frac{1-\phi}{\phi}} \gamma \tau^{\phi-1} \tag{1.A.3}$$

$$\frac{\partial A}{\partial c} = [\gamma \tau^{\phi} + (1-\gamma) c^{\phi}]^{\frac{1-\phi}{\phi}} (1-\gamma) c^{\phi-1} \tag{1.A.4}$$

The technical rate of substitution (TRS) is given by:

$$TRS = -\frac{\frac{\partial A}{\partial \tau}}{\frac{\partial A}{\partial c}} \tag{1.A.5}$$

Substituting (1.A.3) and (1.A.4) into (1.A.5) yields:

$$TRS = -\frac{\gamma \tau^{\phi-1}}{(1-\gamma) c^{\phi-1}} = -\frac{\gamma}{(1-\gamma)} (\frac{c}{\tau})^{1-\phi} \tag{1.A.6}$$

The factors ratio is then:

$$\frac{c}{\tau} = [-TRS(\frac{1-\gamma}{\gamma})]^{\frac{1}{1-\phi}} \tag{1.A.7}$$

Applying the logarithm transformation to (1.A.7), one can compute the elasticity of substitution σ across inputs:

$$\sigma_{APF} = \frac{\partial ln(\frac{c}{\tau})}{\partial ln|TRS|} = \frac{1}{1-\phi} \tag{1.A.8}$$

where APF stems for ability production function. If $\phi > 0$ the elasticity of substitution is high and the inputs are perfect substitutes, so that that a decrease in maternal time due to mother's participation in the labor market can be compensated by an equal amount of time in external child care; instead, if $\phi < 0$ the elasticity is low and the inputs are complements.[19]

[19] Apart from Heckman (2007) that uses a CES production function for the specification of the child development process, the majority of studies using a child ability production function framework adopts a linear (or log-linear) specification, assuming perfect substitutability of inputs across periods and $\phi = 1$

Moreover, the relationship between the elasticity of substitution in the utility function and in the child's ability production function allows to identify potential compensating or reinforcing behavior of parents, that can be interpreted as reactions to the (partially) observed level of child's ability. Consider equation (1.A.1). The marginal utility for each good is defined as:

$$\frac{\partial U}{\partial C} = \frac{1}{\rho}[\alpha_1 C^\rho + \alpha_2 A^\rho]^{1/\rho - 1}[\rho \alpha_1 C^{\rho-1}] \tag{1.A.9}$$

$$\frac{\partial U}{\partial A} = \frac{1}{\rho}[\alpha_1 C^\rho + \alpha_2 A^\rho]^{1/\rho - 1}[\rho \alpha_2 A^{\rho-1}] \tag{1.A.10}$$

The marginal rate of substitution (MRS) is given by:

$$MRS = -\frac{\frac{\partial U}{\partial C}}{\frac{\partial U}{\partial A}} \tag{1.A.11}$$

Substituting (1.A.9) and (1.A.10) into (1.A.11) and solving for the goods ratio yields:

$$\frac{A}{C} = [-MRS\frac{\alpha_2}{\alpha_1}]^{\frac{1}{1-\rho}} \tag{1.A.12}$$

Applying the logarithm transformation to (1.A.12), one can compute the elasticity of substitution σ across inputs:

$$\sigma_{UF} = \frac{\partial ln(\frac{A}{C})}{\partial ln|MRS|} = \frac{1}{1-\rho} \tag{1.A.13}$$

where UF stems for utility function.

The potential compensating or reinforcing behavior of the parents can be derived by the relationship between σ_{UF} and σ_{APF}. Suppose that before making any decisions concerning time and child care use parents (partially) observe their child's ability. Say that, for instance, child's ability has a negative shock after birth so that parents may decide to compensate this shock (investing more in child's human capital) or to reinforce it (by investing less in child's human capital).

If $\sigma_{UF} < \sigma_{APF}$, hence $\rho < \phi$, the elasticity of substitution across goods is smaller than the one across inputs implying that consumption and child's ability are complements in parents' utility. After a negative shock in ability, it is optimal for the parents to compensate and to invest more in the child's human capital. The degree of substitutability between τ and c, i.e., σ_{APF} determines how much the parents invest increasing τ, c or both. Instead, if $\sigma_{UF} > \sigma_{APF}$, hence $\rho > \phi$, it is optimal for the parents to reinforce the effect of the shock investing less in the child's human capital (Almond and Currie, 2011).[20]

(for instance, see Bernal (2008)). Del Boca et al. (2010) and the model presented in chapter 3 of this thesis adopt a Cobb-Douglas specification, where $\phi = 0$ and the elasticity of substitution is equal to 1.

[20]For instance, Bernal (2008) defines the child cognitive ability as linear ($\phi = 1$) and the utility function as CES (CRRA) in consumption and child's ability. She estimates the parameter for child's ability in the mother utility function ρ as being lower than 1, meaning that mothers find optimal to engage in compensating behavior toward their children if their level of initial endowment is low. If both the utility function and the child's ability production function are Cobb-Douglas $\rho = \phi = 0$ and investments do not depend on the shocks.

CHAPTER 2

Exploring the impacts of public child care on mothers and children in Italy: does rationing play a role?

ABSTRACT - This chapter investigates the effects of public child care availability in Italy on mothers' working status and children's scholastic achievements. We use a newly available dataset containing individual standardized test scores of pupils attending second grade of primary school in 2009-10 in conjunction with data on public child care availability. Public child care coverage in Italy is scarce (12.7 percent versus the OECD average of 30 percent) and the service is rationed. Consequently, each municipality allocates the available slots according to eligibility criteria. We argue that when child care coverage is low and these criteria play a stronger role, the effect of a percentage change in child care is stronger. Our estimates indicate that child care availability has positive and significant effects on both mothers' working status and children's Language test scores. Moreover, the effect of a percentage change in public child care on mother's employment and Language test score is greater if child care availability is scarce, i.e., the service is more rationed.

JEL Classification: J13, I2, H75

Keywords: child care, female employment, child cognitive outcomes

2.1. Introduction

Advocates[1] for public intervention in child care provision offer two main arguments: (1) child care providing children's "physical care" may support mothers' participation in the labor market and (2) child care providing early childhood education may contribute to children's cognitive and noncognitive development, leading to gains in the accumulation of human capital in the society.

Existing research on the impact of child care supply on maternal employment has been recently accompanied by growing interest in the impact of child care on childhood development. Such studies suggest that children's cognitive and noncognitive outcomes are largely determined early in life and that returns on investments in early childhood are higher than those on investments at later stages, especially for disadvantaged children (Carneiro and Heckman, 2003). Inputs from families as well as from the school system during early childhood play a very significant role in later cognitive, social, and behavioral outcomes (Heckman, Stixrud, and Urzua, 2006).

Child care institutions are important arenas for children's development, and expanding child care coverage is an explicit goal in many countries. In 2002, the European Union Presidency established the goal of providing "child care by 2010 to at least 90 percent of children between 3 years old and the mandatory school age and at least 33 percent of children under 3 years of age" (EU, 2002).

Exploring the roles of public child care is particularly relevant in Italy, where the labor market participation of mothers is much lower than in other European countries and children do less well in school than their European counterparts. In Italy, only 54 percent of mothers are employed, while this value is over 70 percent in the U.K., France and Germany.[2] Furthermore, according to 2006 data from PISA (the Programme for International Student Assessment), 15-year-old Italian students rank fourth from the bottom in average educational performance among advanced countries (OECD, 2007a).

Given the large number of children from single-child families, their main opportunities for early socialization may be those provided by child care services and investments in child care policies may also help alleviate intergenerational persistence, especially for children from low-income families. Instead, recent data (OECD, 2010) show that public investment in pre-school education in Italy is among the lowest in Europe.[3]

As a result, child care is far less readily available than in other European countries: according to ISTAT (2010), only 12.7 percent of children aged 0-2 years in Italy have access to public child care facilities and, despite the persistence of strong traditional values, which say that the child is better off in his mother's care, the demand for public child care is still higher than supply in all Italian regions. When child care applications outnumber supply, the municipalities, as the main decision makers in child care policies, settle how to allocate the limited number of slots defining eligibility requirements according to their preferences. For example, child care may be limited to children from low income families,

[1]This chapter is a joint work with Daniela Del Boca and Chiara Pronzato (University of Turin and Collegio Carlo Alberto).
[2]Data from Eurostat referred to 2009.
[3]According to data from OECD Family Database for 2005, public expenditure on child care and early education services in Italy is equivalent to 0.6 percent of GDP, while this figure for France, Sweden and Denmark is higher than 1 percent (OECD, 2010).

to provide them educational opportunities and better inputs for their development than those received at home, or to those with working mothers, to support parents' conciliation between parenthood and work.

This chapter explores the role of public child care in Italy, investigating its impact on mothers' working status and children's educational outcomes. We use a newly available dataset on children's primary school performance, in conjunction with data on public child care coverage at the provincial level. Our identification strategy exploits cross-sectional variation in child care coverage across provinces to recover the effects of interests.

This chapter contributes to the existing literature in two ways. First, differently from the majority of studies on this issue, which deals with child care policies for children older than 3, we explicitly deal with *early* child care for children aged 0-2 years. A policy targeted toward very young children may have different effects on both the outcomes, with respect to policies focused on children in preschool ages. Concerning mother's employment, a policy offering external child care for children aged 0-2 may be more effective than a preschool policy in decreasing the probability that mothers without alternative forms of care leave the labor market. Concerning children's outcomes, instead, this study allows to test whether a policy for very young children can have an effect on cognitive outcomes measured at primary schools, as suggested by a recent literature saying that the returns of investments made during early years is higher than that of investments made later one (Carneiro and Heckman, 2003). Second, when considering the impacts of child care coverage on these outcomes, we take into account the potential non-linearity in child care impacts, to see whether they change if the service is more rationed, i.e., less available.

In the base specification, controlling for children's and parents' characteristics as well as provinces' features, we find that child care availability is positively related to mothers' participation in the labor market and to Language test scores. This result is robust to the inclusion of province fixed effects and to a battery of sensitivity checks. Once we allow for a non-linear effect, we find that in areas where the supply of child care is more limited the effect of a percentage change in child care supply on both mother's employment and Language test score is higher.

The rest of the chapter is organized as follows. In section 2.2 we review the existing literature concerning the impact of child care on both mothers' participation and children's cognitive outcomes. In section 2.3 we describe public child care in Italy and its features, with particular attention to eligibility criteria and rationing; in section 2.4 we present a theoretical model, representing the framework for our empirical analysis. In section 2.5 we define the empirical strategy and the issues involved in the estimation, while section 2.6 provides a description of the data and variables used. In section 2.7 we present the results from our estimation; section 2.8 discusses the robustness checks we perform. Section 2.9 presents the results where non-linearity in child care impacts is taken into account. Finally, section 2.10 concludes.

2.2. The Literature

Several studies have analyzed the role of child care as an important tool for reconciling work and family commitments during the childbearing years. Studies in the U.S. have mainly focused on programs for disadvantaged households and children.[4]

According to microeconomic theory, an increase in child care availability lowers the cost of using the service, determining an increase in mother's net wage. However, the final impact on mother's participation is unclear: an higher net wage may determine an increase in mother's participation (substitution effect) or an increase in leisure time (income effect), which one prevails depending on the structure of mother's preferences.

The empirical research analyzing the impact of child care availability reports in fact mixed findings. Havnes and Mogstad (2011a) analyze the impact of a change in child care availability in Norway and find a very small effect on mothers' participation in the labor market, similarly to some studies for the U.S. (Cascio, 2009). Baker, Gruber, and Milligan (2008) evaluate the impact of a public child care program in Quebec (Canada), finding that the introduction of generous child care subsidies led to a strong increase in employment for married mothers.

For Italy, Del Boca (2002), Del Boca and Vuri (2007) and Del Boca, Pasqua, and Pronzato (2009) find a positive impact of child care coverage and child care subsidies on the likelihood that the mother works. In particular, Del Boca and Vuri (2007) take into account the impact of rationing, due to child care system rigidity (in terms of accessibility, opening time and costs), and find that in areas with higher child care availability the probability of female employment increases.

In recent years, economic analyses have also focused on the impact of child care on children's outcomes. In the economics literature on human capital, Becker (1964) has pointed out that the returns to investments in early childhood are likely to be relatively high, simply because of the long time in which to reap the rewards. Carneiro and Heckman (2003) took this argument further, arguing that investments in early childhood have higher returns for children living in disadvantaged contexts. Early childhood educational programs can generate learning gains in the short-run and, in many cases, improve the long-run prospects of children, especially for low-income families.

A number of studies for the U.S. show that the evidence regarding this impact is limited to short-run outcomes and that the findings are mixed. Loeb et al. (2007), for instance, find that pre-primary education in the U.S. is associated with improved reading and Math skills at primary school entry. Positive effects of child care on children's short-run outcomes are also found by Fitzpatrick (2008) but the impacts depend strongly on ethnicity and family income. Other studies (Magnuson, Rhum, and Waldfogel, 2007) confirm these results, showing that the positive effects dissipate for most children already by the end of first grade, while larger and longer lasting associations with academic gains are found for disadvantaged children. Melhuish, Sylva, Sammons, Siraj-Blatchford, Taggart, Phan, and Malin (2008) suggest that children with low educated parents benefit most from child care attendance.

Research from Europe focuses on public child care, which is more widespread than in the U.S., especially in Northern countries. Datta Gupta and Simonsen (2011b) evaluate

[4]See Blau and Currie (2006) and Ruhm (2004) for excellent surveys.

the impact of child care exposure at age 3 on children's cognitive outcomes at age 11, in Denmark. They find that having attended high-quality pre-school (instead of family day-care) has a positive impact on Language and problem solving tests scores, while it decreases the probability of grade retention. Other studies use information on child care coverage at aggregate level, as we do in this study. Havnes and Mogstad (2010, 2011b) find that a substantial change in child care supply in Norway has strong positive impacts on children's outcomes, although the impact is much stronger for children of low educated parents. Their results suggest a positive and significant impact of child care coverage on educational outcomes, such as years of education and college attendance, but also on long-term outcomes, such as adult earnings. Felfe and Lalive (2010), instead, exploit a variation in child care supply in Germany and find positive and significant effects on Language skills in the short run and on school grades in the medium run. Similarly, Berlinski et al. (2009) report a positive effect of a preschool expansion policy in Argentina on both Math and Spanish test scores.

In Italy, the topic of early child intervention and child care impacts on children's outcomes has largely been neglected. Only very recently there has been availability of data on children's outcomes (ISFOL, INVALSI and local data sources referring to specific regions, such as Emilia Romagna and Piedmont), which made it possible to consider the impact of child care not only from the standpoint of physical care but also in terms of its role in educating young children. Del Boca and Pasqua (2010) compare different Italian data sources and show a positive correlation between child care use and subsequent cognitive outcomes of children.

This chapter contributes to the existing literature in the following ways. First of all, it provides evidence of child care impacts in the Italian context. This is important not only because studies on this topic are absent, but also because of the characteristics of this country in terms of child care policy, mothers' employment and children's performances at school. Second, differently from the majority of studies detailed above, we will explicitly consider the child care policy for very young children, aged 0-2 years.[5] Finally, we estimate the impacts of child care availability on mother's working status and children's outcomes taking into account the role of rationing, i.e., scarce availability, in public child care. To do this, we also refer to other related literature that has investigated the functioning of the child care market in Italy and the criteria used to allocate the limited slots to households (Antonelli and Grembi, 2010, Bosi and Silvestri, 2008).

2.3. Child care in Italy

While Italy is ranked quite high for its child care policies for children aged 3-6, it fares much worse for its policies for children under 3: public child care for children aged 3 or older has a utilization rate of 95 percent, whereas public child care for children younger than 3 covers only the 12.7 percent of children aged 0-2 (ISTAT, 2010).

[5]To the best of our knowledge, only Felfe and Lalive (2010) consider the impacts of child care attendance when the child was younger than 3 years old. Instead, the majority of studies consider child care policies for children older than 3 and their attendance to kindergarten or pre-primary schools (for instance, see Loeb et al. (2007), Fitzpatrick (2008), Magnuson et al. (2007) Melhuish et al. (2008) and Datta Gupta and Simonsen (2011b)).

In Italy, the child care policy for children aged 0-2 is decentralized: the municipality is the main decision-maker, while the regions define general management criteria;[6] the central government is only responsible for defining common objective standards and resources allocation among regions.[7] This may explain why the availability of public child care for children under three varies greatly across regions, from around 25 per cent in some areas in the North to under 5 percent in most of the South (see figure 2.1). Furthermore, in the last years, child care supply from private providers has increased and developed differently across Italian regions (Istituto Degli Innocenti, 2002, 2009). Public child care differs from private child care in several ways. For instance, public services are more strictly regulated both in terms of service standards and in terms of management and personnel requirements (Istituto Degli Innocenti, 2002). As stated in Budget Law 2002,[8] one of the most important aim of public child care is educational. This goal has been implemented through the introduction of quality standards, especially in regions with greater experience in child care provision (such as Emilia Romagna and Tuscany). Public child care is also less expensive than the private one, since it is highly subsidized (Del Boca, Locatelli, and Vuri, 2005).

Although it is higher-quality and less expensive than either private child care or baby-sitting services, public child care is used by only a fraction of Italian households. This is the outcome of both families' and municipalities' decisions. Families' decisions are often conditioned by persistent, strongly-rooted cultural norms. In Southern European countries, and Italy in particular, the traditional role of mothers is still highly valued and, hence, mothers are considered the best caregivers for their children. However, as reported in Zollino (2008), not all the households willing to use the service are able to do it, due to scarce availability and waiting lists.

On the supply side, the decisions of the municipalities concerning the number of child care slots to offer depend on their preferences, as to which types of household to target, and on their budget constraint. Each municipality establishes eligibility requirements so that the number of available slots can be assigned to households who benefit more.[9]

While absolute priority is given to applications of children with disability,[10] the other criteria can be classified into two main categories. The first category mainly includes the following eligibility criteria: having both parents working (part-time or full-time), having parents with turns at work or commuting, having other siblings (an higher score is given

[6]To date, in Italy there are 8,092 municipalities in 20 regions.

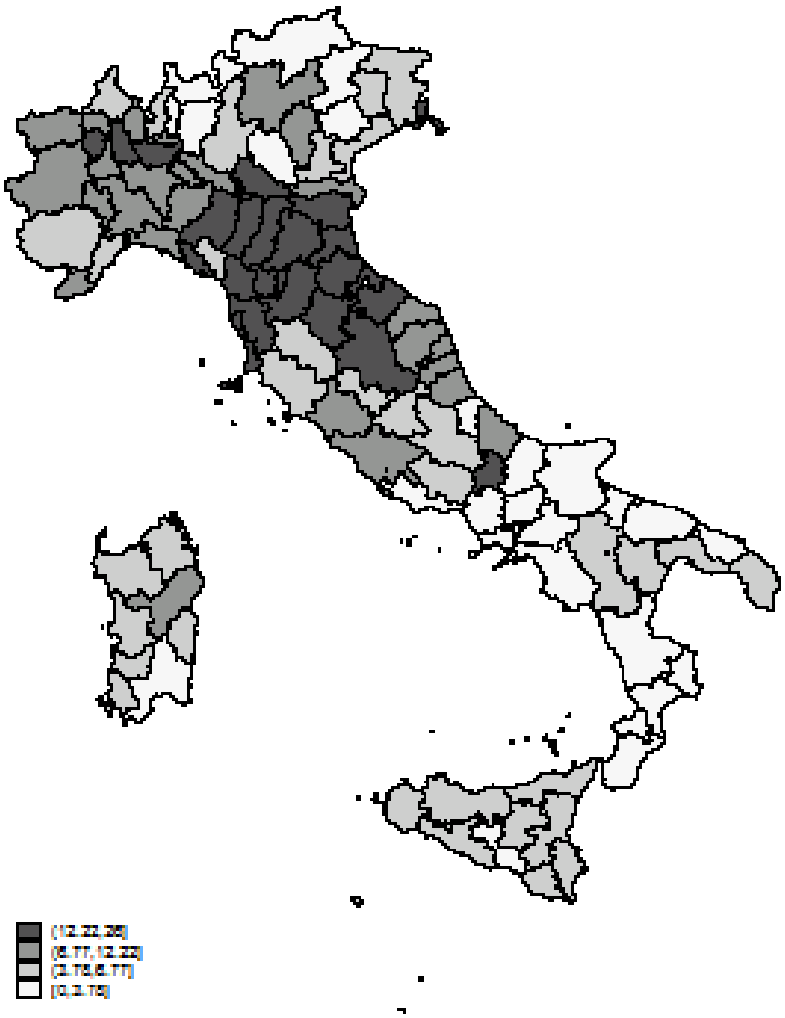
[7]Appendix 2.A provides further details on the institutional and historical background concerning the child care policy in Italy.

[8]Law 448/2001 (Budget Law 2002) defined formal child care as "structures aimed at granting the development and socialization of girls and boys aged between 3 months and 3 years and to support families and parents with young children".

[9]Bosi and Silvestri (2008) argue that the municipality has imperfect information about the real demand of child care, so that eligibility criteria can help the social planner in identifying parents that can be more interested in the service among all potential demanders. In this context, access criteria might be viewed also as a *screening device* used by the social planner.

[10]National Law 104/1992.

Figure 2.1
Child care coverage across Italian regions (percentage ratio between slots and population 0-2 years), 2005.



Source: own elaborations from Cittadinanzattiva (2007).

if siblings are aged 0-2). The second category includes mostly criteria related to the socio-economic conditions of the household, such as being orphan or fostered child, having one or both parents unemployed, living with single parent.[11]

Thus, according to these access criteria, public child care can be viewed both as a tool to help families to reconcile work and parenthood during the childbearing years, and as a social service aimed to support the early education and the social inclusion of children from low income families and stressful environments.[12]

From the social planner's point of view, both outcomes are particularly important for Italy. On one hand, in fact, nearly 30 percent of mothers leave their jobs after the birth of the first child and the probability of leaving the labor market after childbirth is higher for

[11]There may be a third category, including criteria not related to specific social planner's objectives but often used as a priority criterion when candidates have equal scores: for example, being in the waiting list or attending the facility the previous year, household income or the availability of grandparents.
[12]According to Antonelli and Grembi (2010), who collected information on accessibility criteria adopted in a sample of 144 Italian municipalities, the second criterion, that is support the early education and social inclusion of children from disadvantaged backgrounds, seems to prevail.

low educated mothers and in areas with limited child care (Bratti et al., 2005, Pronzato, 2009). Moreover, mothers' participation to the labor market in Italy does not change significantly as the child ages from 0-2 to 3-5 years (OECD, 2007b), while it changes with the birth of a child.[13] This may confirm that childbirth plays a crucial role for mothers' employment carriers and that child care for children 0-2 may soften the negative trend of employment after childbirth, since it may help women without alternative forms of care to remain in the labor market.

On the other hand, among low income households eligible for child care, a growing number of children are from immigrant families implying the importance of institutions favoring their social integration (Dalla Zuanna, Giraldo, and Rettore, 2011).

2.4. Theoretical Framework

In this section, we present a theoretical framework that summarizes the main mechanisms at work when we assess the effects of child care availability on both mother's employment and children's cognitive outcomes.

The municipalities' decisions regarding the supply of child care slots depend on the local budget constraint and preferences of the local government. We assume that local governments aim to encourage women's work and to increase the educational outcomes of children through public child care.

The objective of the municipality is given by

$$U(L, E)$$

where L is the participation of mothers (of young children) and E is an indicator of the educational outcomes of children in the local area. The social planner seeks to maximize her objective by manipulating (final) demand, which is accomplished by using the policy variables at disposal. We assume that the policy variables are: N, the number of public child care slots; P, the price charged each household for a slot; and R, the rules used to assign slots to potential demanders in the case of excess demand at the price P. In this simple model, we assume that the price P is the same for all households in the same municipality, while it can change across municipalities. Given the population of potential demanders (mothers with young children), there exists a set of households that would gain access to public child care under (N, R, P). In this set of households, we say that the number $L(N, R, P)$ would work and that the educational outcome of all children is given by $E(N, R, P)$. Hence, the social planner solves the following maximization problem:

$$\max_{N,R,P} U(L(N, R, P), E(N, R, P))$$

We now consider the constraints on the social planner's choices. A social planner may use rationing as a means to maximize her objective function. For example, if the social planner wants to increase maternal employment, she could do so by limiting access and making maternal employment one of the criteria for acquiring a slot. Different rationing

[13]According to OECD (2007b), maternal employment rate in Italy (for women in the age range 15-64) is equal to 47.3 percent when the youngest child is aged less than 2 years, and equal to 50.6 percent when the age of the youngest child is between 3 and 5 years. Instead, the difference in women participation to the labor market between those without children and those with children aged 0-6 is equal to 8 percent (Commissione Europea, , 2009, Data from Labor Force Survey 2006).

criteria may be utilized if the social planner wants to increase the educational outcomes of children in this population. Viewed in this way, rationing and selective access are outcomes of a mechanism design implemented by the social planner. The monetary constraint the social planner faces is given by

$$C \times N = S + P \times N$$

where C is the cost of each child care slot sustained by the municipality; S are the fixed subsidies that the central government has allocated to the local government; and P, the price per slot sustained by the family. Hence, the number of slots the social planner can provide given S and P is

$$N = S/(C - P). \tag{2.1}$$

As the social planner increases the price (P), the number of slots increases.

We assume that for any N, potential demand is such that there exists a $P^*(N)$ allowing demand to exactly equal supply (N) at that price. In this case, the price serves to "ration" demand, and the rules R are irrelevant: only households with a willingness to pay for child care greater than or equal to P^*would get a slot. This implies that, in such cases, only households with higher income would be able to pay for this service.

Thus, at any P less than $P^*(N)$, there will be excess demand and the rationing rules become operative, selecting potential demanders whose characteristics and choices the social planner values. By lowering the price and creating excess demand, the social planner can choose individuals who acquire the slots instead of having the "market" to do this strictly through the price mechanism. However, there is a cost to this selection, in that fewer slots can be generated. At $P = 0$, the municipality can choose perfectly how to allocate the slots to households which are eligible according to the allocation criteria R. But, in this case, the supply of slots may be very low given that S will be the only source of program revenue.

The final choice of the social planner would involve something in the middle between the case with $P = 0$ and the case with $P = P^*$. The social planner can propose a price lower than P^*, so that there will be excess demand, choosing among the potential demanders using the rules R.

We posit that municipalities with higher availability can provide more slots increasing the price charged to the households. However, if they mostly use the price to ration the demand, they would be able to allocate the slots only to children of wealthier families, where parents are more likely to be high educated and to be both employed. In this case, as confirmed by previous literature (Felfe and Lalive, 2010, Havnes and Mogstad, 2010, 2011a,b), we expect the effect of an additional child care slot to be lower, since the policy has been targeted toward children that would have received better inputs at home and mothers that would have been more likely to combine family and work. Instead, municipalities that cannot charge higher prices would be also characterized by fewer slots and, for them, rules R are more relevant. In this case, instead, the municipality is able to identify households who may benefit more from the policy, both providing to the mother an alternative form of care if she wants to work or offering to children coming from disadvantaged backgrounds better educational inputs. Even though eligibility requirements may

be different across local areas, producing mixed types of eligible households, we expect that when child care coverage is rationed, it has a stronger impact on mothers' working status and on children's educational outcomes, since the social planner is able to select groups which are more likely to benefit from the service.

The same selection may happen at provincial level, that is the level of aggregation we use for the child care variable in the empirical analysis. At provincial level, the availability of child care slots can be a proxy for the choice variables used by the social planner at the municipal level. Assuming that, conditioned on the population aged 0-2, the amount of the subsidy is equal across provinces, from (2.1) we know that the higher is the price the lower the role for the rules R. We argue that provinces with higher availability are also more likely to charge higher prices, since the potential demanders in these areas are richer and have better employment opportunities. However, an additional child care slot in these provinces would have a very low effect on the outcomes, since mothers could have come back at work thanks to other opportunities offered by the province or children could have got good results at school due to other educational inputs. Instead, in provinces where child care availability is lower, the price is also lower and there is more space for the eligibility requirements. Hence, we expect in these areas an higher child care effect on both outcomes.

Notice that this positive selection of provinces in "high child care coverage" may also bias our results if not taken into account. In fact, in the empirical analysis, we are comparing provinces with very high availability of the service (mostly in the Northern part of Italy) with others where child care availability is close to zero (mostly in the South). If the selection described above is not taken into account, we expect to underestimate the child care effects on both outcomes.

2.5. Empirical strategy

We want to investigate empirically the role played by child care coverage when children were aged 0-2 ($t \in (0,2)$) on mothers' probability to work and on children's outcomes in second grade at primary school (when children are aged 7 years, $t = 7$). The relationship between these outcome variables and the availability of child care can be summarized by the following equations:

$$L_{ipt=7} = \alpha_0 + X'_{ip}\alpha_1 + H'_{ip}\alpha_2 + \alpha_3 N_{pt\in(0,2)} + \epsilon_{ipt} \tag{2.2}$$

$$E_{ipt=7} = \delta_0 + X'_{ip}\delta_1 + H'_{ip}\delta_2 + \delta_3 N_{pt\in(0,2)} + \varepsilon_{ipt} \tag{2.3}$$

where L_{ip} is a binary variable equal to 1 if the mother of child i in province p works and E_{ip} is child i's cognitive outcome, measured by child i's scores in Language and Math tests. X_{ip} and H_{ip} represent child's and parents' observable time invariant characteristics.

The variable whose effect is the main interest of this work is N_p, that represents public child care coverage at the level of the province (defined as percentage ratio between available slots and population aged 0-2 years) and is an indicator of the likelihood that the child attended child care.[14]

[14]The INVALSI wave 2009-10 that we are using actually contains a question regarding individual child care attendance during infancy. However, this information cannot be used in a credible manner, since it is characterized by almost 40 percent of (non-random) missing values.

The estimated coefficients of interest comprise the effect of child care attendance on the individual plus the effect given by the fact that other individuals in the same province have been more likely to use it too. Formally, since N is defined as the percentage child care coverage over the population aged 0-2 years, α_3 and δ_3 in equations (2.2) and (2.3) represent reduced form estimates of the effects of a percentage change in nursery availability on all children, including any indirect or spillover effects. Hence, we identify the Intention to Treat effect (ITT) rather than the effect on the children affected by the child care policy (the effect of the Treatment on the Treated - TT). In order to understand the importance of spillover and indirect effects in this framework, let us provide some illustrative examples. In case of children's outcomes, we may think that a child in a primary school may benefit not only from his own child care experience but also from staying in a class where many children have been attended child care; thus, the coefficient estimate δ_3 represents the full effect of child care "exposure"on all children in a province, not only on those who actually attended child care. In the case of mother's work, instead, we may expect that the cost of participating in the labor market is lower if the mother has a child care slot available but also if other mothers of young children participate too.[15]

The parameters of interests capture the average effect of a percentage change in child care availability on all children. Notice that we are averaging over two dimensions: first, we average over all children living in different provinces; second, we average across marginal effects of the additional child care slot that can be heterogeneous in the population. This second dimension is particularly important, since we are measuring both outcomes when the child is enrolled at primary school, after several years from the exposure to the treatment. Our results are directly comparable with other studies using child care information at aggregate level and recovering ITT estimates (e.g. Havnes and Mogstad (2011a) and Berlinski and Galiani (2007) for child care effects on mother's employment and Berlinski et al. (2009) and Felfe and Lalive (2010) for impacts on children's cognitive outcomes).

Apart from the observable characteristics X_{ip} and H_{ip}, there are of course other unmeasured characteristics of the household, the child and the province where the household resides that are important determinants of the mother's labor market participation and children's cognitive outcomes, which are reflected in the disturbance term ϵ_{ipt} and ε_{ipt}. The disturbances have a group structure and are defined as follows:

$$\epsilon_{ipt} = \alpha_p(t) + \omega_{ip}(t) \tag{2.4}$$

$$\varepsilon_{ipt} = \delta_p(t) + \upsilon_{ip}(t), \tag{2.5}$$

where α_p and δ_p are province-specific components, assumed to be normally distributed, while ω_{ip} and υ_{ip} stand for disturbance errors at individual level.

In order to take into account the error components at provincial level, we estimate the above equations using GLS (or Random Effects -RE) model.[16] Moreover, since we are

[15]These spillover effects have been also considered in the literature on social interactions and networks. For instance, Maurin and Moschion (2009) focus on the interaction of mothers in the same neighborhood as a determinant for their participation decisions.

[16]Concerning equation (2.2), results do not differ using probit or logit instead of GLS. When estimating equation (2.2) with GLS we also correct the standard errors for heteroskedasticity.

using mixed-level data, including information at the individual and provincial levels, it is likely that observations in the same province are not independent, so standard regression techniques attribute too large levels of statistical significance to coefficient estimates (Moulton, 1990). Following Primo, Jacobsmeier, and Milyo (2007), we adopt cluster-adjustments of the estimates of the standard errors to account for non-independence of observations within the same province.[17]

We can consistently estimate the child care effects α_3 in equation (2.2) and δ_3 in equation (2.3) if the following conditions hold: (i) both the error components (at individual and provincial levels) are uncorrelated with the included regressors; (ii) the error terms are uncorrelated one with the other, i.e., once we take into account the unobservables at provincial level, the ones at individual level are uniformly distributed across provinces.

Using the aggregate number of slots available in the local area allows to claim that there is little scope for endogeneity between the child care measure and the individual component of the disturbance terms in any equation. In fact, using information on child care coverage at provincial level avoids the usual problem of selection and sorting of children and parents in individual child care attendance. However, we can still have a non-zero correlation between the child care measure and the unobservables at individual level if local entities create policies in a purposive manner to respond to underlying economic, social or cultural conditions. Actually, this might be more likely to happen if we were using information on child care coverage at the municipal level, since the municipality is the actual decision maker for child care policy (see Section 2.3). Within a province, there may be differences across municipalities, that are equalized by using this information at an higher level of aggregation. For instance, in any province, apart from the main municipality (called, in Italian, *capoluogo di provincia*), there are other smaller municipalities and rural areas. It is reasonable to think of the main municipality to provide higher child care coverage than the smaller municipalities, and this may respond to attitudes of the inhabitants of big cities if they are more willing to use external child care. Using the information at provincial level allows to avoid the potential endogeneity between the municipality decision concerning child care coverage and the unobservables characteristics of individuals, since we are averaging the child care effects over all municipalities in the same province. However, to test whether other unmeasured characteristics of the municipality play a role, we replicate the analysis splitting the sample in two groups according to whether a household resides in the main municipality or in a smaller municipality in the same province.

Further, due to the high diversification of child care coverage across Italian regions, it is very likely that provinces already providing this service during early 2000s are systematically different from provinces with almost a zero child care supply. This implies a positive selection of provinces that, already by 2005, provide the service. If this is the case, then the child care coverage at provincial level is correlated with unobservables characteristics of the province that we cannot control for in the estimation and the coefficient of interests in equation (2.2) and (2.3) are very likely to be biased. The direction of the bias mostly depends on the relationships between the outcomes and the provincial characteristics related to the child care policy. If an higher child care availability is correlated with higher

[17]We adjust standard errors for 101 clusters, i.e., the number of provinces in our sample.

educational investments on children or higher involvement of the social planner in providing conciliating policies, these confounding factors may determine better school outcomes and higher mothers' participation to the labor market regardless of child care coverage.

We try to take into account these issues including province-level regressors that reflect provincial resources, provincial investments in education, and provincial features of the labor market. All these factors can be correlated with provincial child care coverage and can have an influence on the outcomes of interest. Equations (2.2) and (2.3) therefore become:

$$L_{ipt=7} = \alpha_0 + X'_{ip}\alpha_1 + H'_{ip}\alpha_2 + \alpha_3 N_{pt\in(0,2)} + W'_{pt}\alpha_4 + \nu_{ipt} \tag{2.6}$$

$$E_{ipt=7} = \delta_0 + X'_{ip}\delta_1 + H'_{ip}\delta_2 + \delta_3 N_{pt\in(0,2)} + W'_{pt}\delta_4 + \phi_{ipt} \tag{2.7}$$

where W includes GDP per capita, enrollment rate at kindergarten, percentage of graduates, the average school size per province and its square and the employment rate in public services and health-social services where women are overrepresented. ν_{ipt} and ϕ_{ipt} are composite error terms as defined by (2.4) and (2.5).

We also consider a specification, estimated using OLS, where we include provincial fixed effects that capture time invariant unobserved heterogeneity.[18] Specifically, the fixed effects cancel out the error component at province level in (2.4) and (2.5) if it is constant over time, i.e.:

$$\alpha_p(t) = \alpha_{pt=7} = \alpha_{pt\in(0,2)} = \alpha_p$$

$$\delta_p(t) = \delta_{pt=7} = \delta_{pt\in(0,2)} = \delta_p$$

In this way, we can control for the provincial characteristics that we cannot observe but that affect child care availability in 2005 (the year in which we measure child care availability) and the outcomes in 2009-10 (the year in which we measure the outcomes). This long time gap ensures that the characteristics we are controlling are somehow related to the historical background of the province, determining its child care provision during early 2000s. However, the cross-sectional nature of our data prevents, for instance, from taking into account the long-lasting effect of temporary shock increasing child care coverage around 2005. Hence, our results may still be biased by provincial time-varying components that we cannot control for.

Concerning the individual components of the error terms, we should take into account that they may include unobservables of both mothers and children (e.g. ability). Mother's ability is very likely to be correlated with education and employment decisions; moreover, child's ability can be correlated with his parental background, included in the model

[18] In this case, the base model turns to the so-called cluster dummy variables model, as defined in Cameron and Trivedi (2005). Notice that in the base specification we use cluster-adjustments of the estimates of the standard errors, with the number of clusters being equal to the number of provinces in the sample. However, when standard errors are adjusted for clusters, the F-test for the joint null that all coefficients (except the intercept) are equal to zero is able to test at most (M-1) restrictions, where M is the number of clusters in the sample. If the number of parameters to be estimated (i.e., the number of restrictions for the F-test) is higher than the number of clusters it is not possible to recover the F-statistics. This happens when we estimate the cluster dummy variables model (with the province dummies plus all the regressors used in the base specification) and we still adjust the estimates of the standard errors for clusters. Thus, we present the results from the cluster dummy variables model without cluster-adjustment of the standard errors.

through mother's and father's education, H_{ip}. Since the correlation between the individual components of the error terms and the individual (parents' and children's) characteristics in both equations is very likely to be different from zero, the coefficient estimates of these variables are likely to be biased in both equations. Therefore, we cannot claim a causal impact of any of the variables indicating parents' and children's observable characteristics.

Finally, we should discuss an additional issue we face in the available data, i.e., measurement error. In fact, in conjunction with our sample of children attending second grade in 2009-10 the most appropriate measure of child care coverage would be in 2003-2004 (when the children in our sample were aged 0-2 years). However, data on public child care coverage at provincial level are available only for 2005. The measure of child care coverage that we observe is $N_{pt\in(1,3)} = N_{pt\in(0,2)} + \xi_p$, where $N_{pt\in(1,3)}$ is the available measure for 2005, and ξ_p represents the growth in child care supply between 2003-04 ($N_{pt\in(0,2)}$) and 2005. This measurement error, i.e. the difference between the observed child care coverage in 2005 and the "true" child care coverage in 2003-04, is part of the error term in both equations. In order to get consistent estimates for child care impacts, we need to assume measurement error as having zero mean and being uncorrelated with the observed measure of child care. In other words, it implies that the difference in child care supply between 2003-04 and 2005 is uncorrelated with other unobservable characteristics, at province level, which affect the outcomes of interest; similarly, if there has been a growth in child care provision during this period, it has been uniform across Italian provinces. Although detailed information on provincial child care supply in the period 2003-2005 is missing and, to the best of our knowledge, the only information for this period is at national level, several institutional reports (ISTAT, 2011, Istituto Degli Innocenti, 2009) confirm that child care growth has been very limited in these years. Thus, we may argue that child care coverage in 2005 can be considered a good proxy for child care coverage in 2003-04. To increase the confidence in our identification strategy and data, we test the role of measurement error by replicating the analysis using INVALSI data for the school year 2008-09. Children in this survey would have been aged 0-2 in the years 2002-03, so that the measurement error would be much higher in this case.[19]

2.6. Data and Variables

We use individual data on children's primary school outcomes in conjunction with information regarding public child care coverage at the provincial level. Table 2.1 gives the definition of each variable, together with the source of the information we use, while table 2.2 provides some descriptive statistics.

Data on children's cognitive outcomes are taken from the Italian Institute for the Evaluation of the Education System (INVALSI) for 2009-2010. Since the school year 2008-09, INVALSI and its National Evaluation Service (SNV) provide the only ongoing national survey of students' educational achievements at primary school. These assessments measure the abilities of students in second, fifth and sixth grades (ISCED levels 1 and 2).[20]

[19]Using the notation applied before, the relationship between the observed measure of child care in 2005 (when children have between 2 and 4 years) and the true child care supply faced by children assessed in s.y. 2008-09 can be summarized by $N_{pt\in(2,4)} = N_{pt\in(0,2)} + \Xi_p$ with $\Xi_p \geq \xi_p$.

[20]See Appendix 2.B for details on INVALSI data and on the design and implementation of INVALSI assessment.

Table 2.1
Definitions of variables

	Variable's description	Source
OUTCOME VARIABLES		
Mother's working status	Dummy equal to 1 if the mother works (2009-10)	INVALSI SNV
Language test score	Percentage of correct answers in Language test (2009-10)	INVALSI SNV
Math test score	Percentage of correct answers in Math test (2009-10)	INVALSI SNV
CHILD CARE VARIABLES		
Child care coverage	Public child care slots over population 0-2 years by province (2005) (*100)	CITTADINANZATTIVA
CONTROL VARIABLES (INDIVIDUAL LEVEL)		
Male	Dummy equal to 1 if male	INVALSI SNV
Non-Italian	Dummy equal to 1 if the child has not Italian citinzenship	INVALSI SNV
Father tertiary education	Dummy equal to 1 if the father has tertiary education	INVALSI SNV
Mother tertiary education	Dummy equal to 1 if the mother has tertiary education	INVALSI SNV
Family information missing	Dummy equal to 1 if the child has family information missing	INVALSI SNV
Child information missing	Dummy equal to 1 if the child has individual information missing	INVALSI SNV
CONTROL VARIABLES (PROVINCE LEVEL)		
GDP *per capita*	Gross Domestic Product *per capita* (2008 Hundreds Euro)	CAMERA DI COMMERCIO
Pre-Primary enrollment rate	Percentage of children aged 3-5 enrolled at Pre-Primary School (2006-07)	MIUR
Private Primary Schools	Percentage of private primary schools over total schools (2008-09)	INVALSI SNV
School size	Average number of students in Second Grade (2009-10)	INVALSI SNV
Graduates	Percentage of graduates over all population (2001)	CENSUS
Employment rate Public Services	Percentage of employed in public services over total employment (2001)	CENSUS
Employment rate Health-Social Services	Percentage of employed in health/social services over total employment (2001)	CENSUS

In addition to test scores, INVALSI provides information on the children's and parents' characteristics reported by the schools. Thus, the data include individual-level covariates indicating gender, citizenship, parents' working status and education. However, missing information on family characteristics represents almost 25 percent of observations and missing data on the children's personal characteristics are almost 3 percent. Even though missing data may not be systematically linked with our analysis, we do not drop observations without this information and we include as regressors dummy variables indicating whether family or child information is missing.[21]

For our analysis, we rely on data concerning second grade students in the school year 2009-10. In this survey INVALSI assessed the overall population of students enrolled in second grade and designed a sample of schools and students that performed the tests under the supervision of an external inspector. Since several studies found evidence of cheating behavior during the test in not sampled schools (Bertoni, Brunello, and Rocco, 2012, Ferrer-Esteban, 2012, Lucifora and Tonello, 2012), in order to improve the reliability of the results, we focus our analysis only on sampled schools and students. Out of 462,960 observations in second grade, the final sample includes students in sampled schools that took both the Language and Math tests, yielding a sample of 33,708 observations. In the estimation of the mother's work equation we keep only observations without family information missing, ending up with 25,287 observations.

We consider three dependent variables. The first is a dummy equal to one if the child's mother works when the child is enrolled in second grade (aged 7 years, if regular in his school path), and equal to zero otherwise. Some considerations should be done concerning this timing and the fact that we observe mother's work only when the child is enrolled in second grade. Actually, we do not have information on mothers' work history neither on mothers' employment status before and after childbirth. Due to the limitations and the cross-sectional nature of our data, we can only interpret the parameter of interest in equation (2.6), α_3, as an average effect. Given the level of child care available, mothers may behave (in terms of employment decisions after childbirth) in different ways. While

[21]In order to further analyze this point, we perform a probit regression using as dependent variable a dummy variable indicating whether any family information is missing. Results are shown in Appendix 2.C, table 2.B.1.

some of them would have interrupted employment after childbirth, regardless of child care availability, others may have had the opportunity to go back to work even if child care were not available. Only those "at the margin" would have benefited from child care availability, in the sense that the additional child care slot may have increased their probability to continue working. Recent studies show that in Italy female employment is a very "persistent" phenomenon in women's life cycle and that work interruption after childbirth crucially affects women's career and their future employment (Bratti et al., 2005, Del Boca and Sauer, 2009). Thus, we may argue that child care availability might play a role for women working before childbirth, because it may weaken the negative trend of female employment after childbirth. Instead, child care might have no or very low effect for women not working before childbirth. The coefficient for child care coverage represent an average between these heterogeneous impacts. As we can see from table 2.2, almost 60 percent of children in the sample has the mother participating in the labor market.[22]

Table 2.2
Descriptive Statistics.

	Mean	**SD**	**Median**	**Min**	**Max**
Outcome Variables					
Mother's working status	0.60	0.48	1	0	1
Language test score	62.20	22.96	65.38	3.84	100
Math test score	57.26	18.68	57.14	3.57	100
child care Variables					
child care coverage	7.98	5.81	6.58	0.32	25.47
Control Variables					
Male	0.51	0.50	1	0	1
Non-Italian	0.09	0.28	0	0	1
Father tertiary education	0.15	0.36	0	0	1
Mother tertiary education	0.18	0.39	0	0	1
Family information missing	0.25	0.43	0	0	1
Child information missing	0.03	0.17	0	0	1
GDP *per capita*	226.19	57.73	234.37	127.31	367.632
Pre-Primary enrollment rate	75.65	2.77	75.60	67.65	83.66
Private Primary Schools	22.31	20.03	17.95	0	100
School size	84.824	16.57	86.35	39.11	125.36
Graduates	7.85	1.87	7.68	4.41	12.92
Employment rate Public Services	5.27	1.13	5.12	3.26	8.21
Employment rate Health-Social Services	6.84	0.99	6.78	4.617	9.53

The other two dependent variables refer to children's scholastic achievements. They represent children's scores in Language and Math tests provided by INVALSI. Since these tests are composed by multiple-choices questions, the final test score is built as percentage of correct answers over the total number of questions. As shown in Table 2.2, children perform better in Language than in Math, being the average test score in Language 62.2, while the average score in Math is only 57.3.

[22]This value is close to the average participation rate of mothers aged 25-54 with children in the age range 6-11, that is 61 per cent (Eurostat data referred to 2009).

Child care coverage is defined as the percentage ratio between public child care slots and the population aged 0-2 years, by province. The data refer to 2005 and are taken from Cittadinanzattiva (Cittadinanzattiva, 2007), an independent organization that runs yearly surveys to monitor supply of public services, such as child care. Specifically, Cittadinanzattiva gathers the information on the number of slots available for each municipality from the Ministry of Interior and then reports the number of slots for each province (see Cittadinanzattiva (2007) from page 14 on). The variable of interest has been defined dividing the number of slots available in each province by the population aged 0-2 in the same year and in each province; this information includes only public child care services, i.e., publicly provided services in publicly owned facilities (Cittadinanzattiva, 2007).[23] This is the only source of data on child care coverage in Italy with a sufficiently disaggregated level of information (province level). [24]

As we can see from table 2.2, public child care coverage is, on average, around 8, and the median child care availability is equal to 6.6. Child care is also highly differentiated across Italian provinces, ranging from values close to 0 in some Southern Italian areas to more than 25 percent in some Northern Italian areas.

As stated in table 2.1, we use several control at individual level exploiting the information gathered by INVALSI. Specifically, we control for child's gender and citizenship, mother's and father's education as well as for having some individual or family information missing.[25] As Table 2.2 shows, fifty percent of the children are male, and 8 percent of them has not Italian citizenship.[26] Finally, we do not have information on parents' education or mother occupation for 25 percent of the sample, while for 3 percent of children we lack information on gender or citizenship.

Finally we use other variables at the province level to control for provinces' characteristics in the estimation. Specifically, we add information related to provincial resources and expenditure for education, as well as variables related to specific labor market features.[27] As a general indicator for the wealth of the province, we include GDP *per capita*. Instead, the enrollment rate of 3-5 years old children in pre-primary school during the

[23]In Italy there may be three types of child care provision: the first one refers to the cases where the public entity (i.e, the municipality) is both the owner and the provider of the service; the second, instead, refers to the cases where the municipality is the owner of the facility but outsources the provision of the service to other private entities; finally, there may be some cases where the private sector is both the owner and the provider of the service and does not receive any form of subsidies from the public sector. For this analysis we use data concerning the first type of management. See appendix 2.A for additional details.

[24]The other official sources of information on child care coverage at aggregate level are ISTAT (Italian National Statistical Institute) and Istituto Degli Innocenti (a public corporation charged by the Italian Government to carry out analysis on childhood and adolescence starting from 1997). However, both of them provide information only at regional level for the period relevant for this study, i.e., years 2002-2003. Hence, data from Cittadinanzattiva remain the most suitable for our analysis.

[25]With child missing information we mean that child's gender or citizenship is not available in the data; instead, the variable family missing information is equal to one if mother's or father's employment or education are missing.

[26]Children without Italian citizenship include both children born abroad and children born in Italy with both parents of foreign origin. Italian law is based on the principle of *jus sanguinis*: children of foreign parents are foreign citizens up to their 18th birthday, then they may apply for Italian citizenship. The percentage of foreign children in the sample corresponds to the one of the entire population (MIUR, 2009).

[27]Data for GDP *per capita* by province are taken from Camera di Commercio, Statistical Service; data on pre-primary enrollment rate are taken from Italian Ministry of Education (MIUR); the percentage of private primary schools and the average school size per province have been provided by INVALSI, Statistical Office; finally, the percentage of graduates over all population, the employment rate in public services and the employment rate in health and social services are taken from CENSUS 2001 data.

school year 2006-07, together with the percentage of private primary schools (over the total number of schools),[28] the average school size for each province [29] and the percentage of graduates over the population reflect provincial characteristics related to the education system and to the overall expenditure for all levels of education. However, the enrollment rate of children in pre-primary school may serve also to test whether conciliation policies for children aged 0-2 and 3-5 years may have different impacts on mother's working status. Last, in order to capture province's features related to labor market opportunities for women, we include some controls for the composition of labor demand (e.g., provincial industrial structure). Specifically, as underlined in several studies referred to Italy and confirmed also by our data,[30] women are overrepresented in sectors like social services and health and public sectors. Thus, we include as regressors the provincial employment rate in public services and in health or social services.[31] Notice that, apart the information on the school characteristics on which the child is currently enrolled, constrained to the availability of data, we include controls at provincial level referred to the year of childbirth or before the period when the outcomes are measured.

Table 2.2, in the panel at the bottom, shows some descriptive statistics for these variables at provincial level. GDP, on average, is equal to 226 hundreds of Euro, and ranges from 12 to 36 hundreds of Euro. Pre-primary enrollment rate is, on average, 75 percent and, already by 2006-07, close to being universally used by children aged 3-5 years. This also confirms the strong differences existing in child care policies in Italy for children aged 0-2 with respect to those for children aged 3-5. The average percentage of private primary schools per province is slightly higher than 22 percent, while the average school size in second grade is close to 84 students per school. Finally, the proportion of the population having a degree is only 7.85 percent (with the maximum being only 12.92 percent), while the average employment rates in public services and health-social services are, respectively, 5.27 and 6.82.

Figures 2.2 and 2.3 report the correlations between child care coverage and the outcomes of interest at the regional level. Regions with higher child care coverage are characterized by higher mothers' employment rate and better results in Language test scores: correlation coefficients between child care coverage and both mother's working status and average Language test score are positive and statistically significant, while they are not statistically significant for Math.

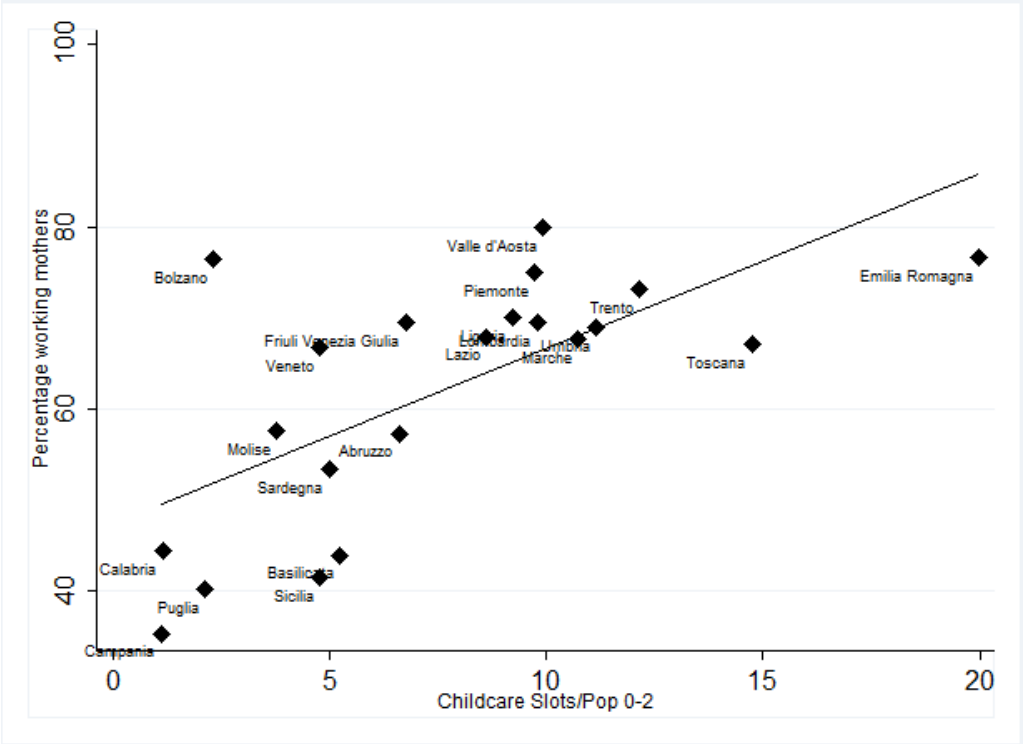
[28]With private primary schools we refer to primary schools that are not public, but still recognized by the National Education System and Ministry of Education. Note that all primary schools in Valle d'Aosta (Aosta province) and Trentino Alto Adige (Trento and Bolzano provinces) are defined as private by the Italian Ministry of Education and INVALSI because of a particular degree of accountability and autonomy of schools located in these regions.

[29]In the baseline specification, we include the average number of students in second grade, by province, and its square.

[30]In our INVALSI data we have information on the industrial sector of both mothers and fathers of children enrolled in second grade, although we cannot know whether that occupation is in the private or in the public sector. For instance, among those for which this information is available (not missing), 21 percent of mothers works in the third sector against 14 percent of fathers.

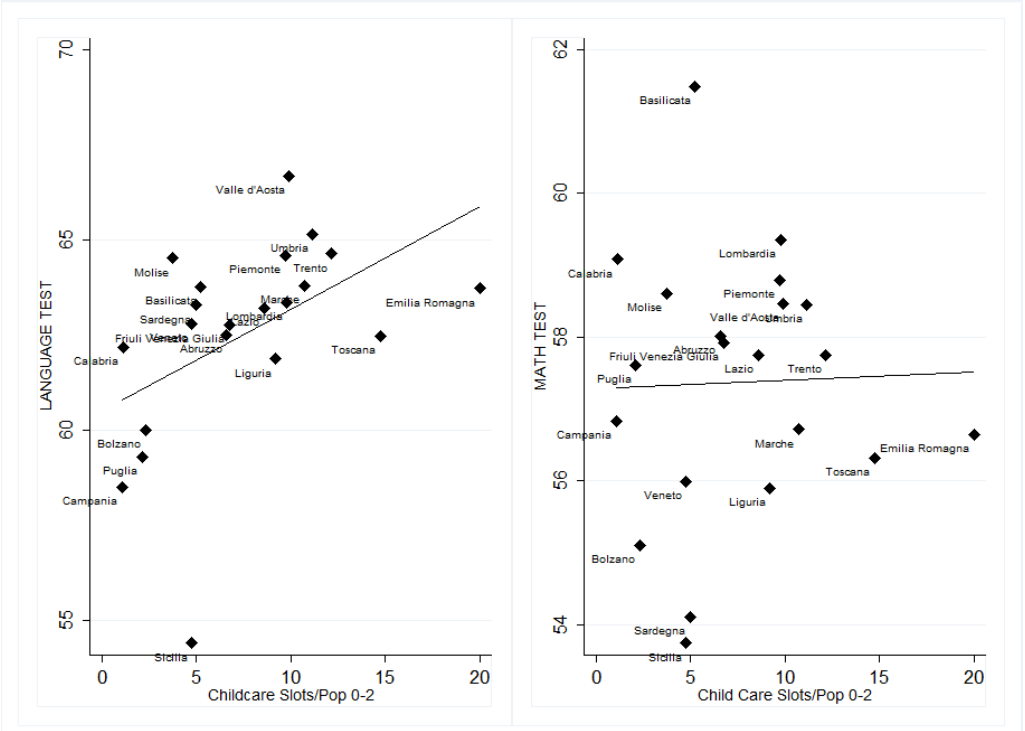
[31]The public services sector includes all employed people in the following occupations: social and public services, personal and domestic services and child care/family care workers, according to the International Standard Classification of Occupation (88) on which the CENSUS 2001 classifications are based.

Figure 2.2
Correlation between mother's working status and child care coverage, by region.



Notes. Correlation coefficient: 0.6702; p-value: 0.0009. Own elaborations from INVALSI SNV 2009-10 and Cittadinanzattiva (2007).

Figure 2.3
Correlation between Language and Math test scores and child care coverage, by region.



Notes. Correlation coefficients: for Language 0.4787 (p-value 0.0282); for Math 0.0301 (p-value 0.8969). Own elaborations from INVALSI SNV 2009-10 and Cittadinanzattiva (2007).

Table 2.3
Test of samples differences across equations. Mean characteristics of all sample (a) with respect to the subsample used in Equation 1 (b).

	(a) All sample	(b) Sample in Eq. 1	t test (a=b)
Male	0.4925	0.4915	−0.26
	(0.003)	(0.003)	
Non-Italian	0.0884	0.0687	−8.89***
	(0.001)	(0.001)	
Mother education (tertiary)	0.1479	0.19	12.28***
	(0.002)	(0.002)	
Father education (tertiary)	0.1214	0.15	11.12***
	(0.002)	(0.002)	
Child care coverage	7.9841	7.8071	−3.66***
	(0.032)	(0.365)	
GDP *per-capita*	226.19	225.92	−0.57
	(0.314)	(0.361)	
Pre-primary enrollment rate	75.6474	75.5675	−3.49***
	(0.015)	(0.017)	
Private primary schools	22.3145	21.983	−2.01***
	(0.109)	(0.124)	
School Size	109.5074	109.9396	2.51*
	(0.116)	(0.1315)	
Graduates	7.8498	7.7713	−5.09***
	(0.0102)	(0.0115)	
Employment rate Public Services	5.2705	5.2277	−4.56***
	(0.006)	(0.007)	
Employment rate Health-Social Services	6.8451	6.7987	−5.68***
	(0.00)	(0.00)	
N	33708	25287	

Notes: t-test for the null hypothesis of equal mean in the two samples (a-b). Standard errors in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

2.7. Results

In this section we discuss the results of the baseline estimation. When estimating the first equation in which mother's working status is the dependent variable, we only keep observations without missing data on family characteristics, which reduces the sample to 25,287 observations. In table 2.3 we compare the mean characteristics in the different samples used for the estimation. Since we find statistically significant differences in some of the individual and province level variables, we also repeat the analysis for the test score equations keeping the same number of observations used to estimate equation (2.6). The results from this check and additional robustness analyses are presented in section 2.8.

Table 2.4 reports the results for all the dependent variables. For each variable, we use two specifications: in the first we use GLS adding controls at provincial level, while the second uses OLS further including province fixed effects.

Column (a) shows the result for mother's work. The coefficients of child care coverage is positive and statistically significant in both the specifications: an increase of 10 percentage points in child care coverage increases the mother's probability of working by 13 to 18 percentage points; this corresponds to an increase in the probability that the mother works when the child is at primary school by 0.2 to 0.4 points of standard deviation. As discussed in the previous section, mother's working status is observed when the child is enrolled in second grade. Even in provinces where child care 0-2 is scarce, a number of mothers have had the opportunity to go back to work thanks to other forms of care available when their children were 0-2 or when their children were enrolled in kindergarten

Table 2.4
Estimates from the base model.

	(a) Mother's working status		(b) Language test score		(c) Math test score	
	GLS	Prov.FE	GLS	Prov.FE	GLS	Prov.FE
Child care coverage	0.013***	0.018***	0.195***	0.482***	−0.001	−0.071
	(0.002)	(0.004)	(0.069)	(0.110)	(0.055)	(0.091)
Male	−0.001	−0.001	−2.531***	−2.517***	1.642***	1.652***
	(0.006)	(0.006)	(0.252)	(0.242)	(0.254)	(0.201)
Non-Italian	−0.311***	−0.315***	−15.660***	−15.714***	−7.310***	−7.317***
	(0.018)	(0.012)	(0.565)	(0.430)	(0.512)	(0.357)
Father tertiary education	0.058***	0.058***	5.813***	5.828***	3.743***	3.757***
	(0.014)	(0.008)	(0.397)	(0.419)	(0.398)	(0.348)
Mother tertiary education	0.258***	0.257***	7.338***	7.308***	4.707***	4.697***
	(0.017)	(0.007)	(0.385)	(0.387)	(0.335)	(0.321)
GDP per capita	0.001***	0.002***	0.012*	0.024**	0.006	0.016*
	(0.000)	(0.000)	(0.007)	(0.012)	(0.006)	(0.010)
Pre-primary enrollment rate	0.000	0.003	0.114	0.477***	0.055	0.466***
	(0.005)	(0.003)	(0.204)	(0.111)	(0.157)	(0.093)
School Size	0.002	0.005	−0.081	0.197*	−0.085	−0.175*
	(0.002)	(0.003)	(0.086)	(0.109)	(0.079)	(0.090)
School Size Squared	−0.000	−0.000	0.000	−0.001**	0.000	0.001*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Private primary schools	0.001***	0.000	0.010	−0.001	−0.000	−0.046*
	(0.000)	(0.001)	(0.016)	(0.029)	(0.012)	(0.024)
Graduates	−0.012	−0.025	0.076	−0.438	0.004	−1.971***
	(0.011)	(0.035)	(0.394)	(0.878)	(0.357)	(0.729)
Employment rate Public Services	0.015	−0.024	−0.546	−0.645	−0.655	0.369
	(0.016)	(0.022)	(0.663)	(0.686)	(0.651)	(0.570)
Employment rate Health-Social Services	−0.011	−0.010	−0.750	−1.656	−0.077	0.698
	(0.011)	(0.017)	(0.482)	(1.023)	(0.349)	(0.850)
Child&Family Missing Info	*X*	*X*	*X*	*X*	*X*	*X*
Province Dummies		*X*		*X*		*X*
N. Clusters	101		101		101	
N.Observations	25287	25287	33708	33708	33708	33708

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level for GLS estimation and robust for heteroskedasticity in column (a).

or in primary school. So, this means that differences in mothers'employment rate across provinces are mitigated by the fact that mothers are observed when children have access to pre-primary and primary school, which are more homogeneously distributed. The fact that we still find a positive impact of child care coverage on mother's work, although controlling for pre-primary enrollment rate and other labor market features, means that care opportunities provided by child care services play a crucial role in helping mothers to keep their job after childbirth. Thus, child care availability may weaken the negative relationship between mother's employment and fertility and decreases the likelihood of work interruption after the birth of a child. As a confirmation of this point, it should be noted that the coefficient for pre-primary enrollment rate is not statistically different from zero.

Notice that our results are slightly higher than the ones previously found by Berlinski and Galiani (2007) and Havnes and Mogstad (2011a). Berlinski and Galiani (2007) evaluate the effects of a preschool policy in Argentina and find that one additional stock in preschool availability yields an increase in mother's employment rate by 7 percentage points, while Havnes and Mogstad (2011a) estimate a percentage point increase in maternal employment rate per percentage point increase in child care coverage equal to 0.011. Our estimate of the percentage change in mother's employment due to a percentage point increase in child care coverage is equal to 0.013, while the impact of a new slot in external child care (with respect to the average of 7.98) corresponds to 16 percentage points. The difference may depend on the fact that we are considering child care for very young children instead of preschool. In the Italian context, where mothers who leave the labor market after childbirth do not have many opportunities to come back at work, a policy

targeted toward very young children can be more effective than other policies for children in the age range 3-5. Moreover, in Northern Europe countries, such as Norway, mothers can rely on additional services to come back at work after childbirth, so that a policy increasing preschool availability may not have an impact on mother's employment.

Child's gender is not significantly associated with mother's working status, while immigrant status does matter: mothers of non-Italian children are less likely to work than those of Italian children; the coefficient for being non-Italian is negative and significant. Mothers' working status, as expected, is strongly and significantly associated with her education, confirming previous results in this strand of the literature, especially for Italy (Del Boca et al., 2009). The same is true for father's education: mothers married to highly educated partners are more likely to work, indicating "assortative mating" between partners, even though the coefficient is lower than for mother's education. Among other controls at provincial level, GDP has a positive effect on mother's employment status while all other variables (with the only exception of private primary schools) do not influence mother's working status.

In columns (b) and (c) of table 2.4 we report the coefficients for Language and Math test scores. Child care coverage affects positively Language test score, while its impact on Math is not statistically different from zero. According to the results for Language test score, a 10 percentage points increase in child care availability is associated with an increase in Language test scores ranging from 1.9 to 4.8 points: the magnitude of this effect implies that a percentage change in child care coverage yields an increase on the Language test score by 0.8 to 2 percent of a standard deviation. This result is in line with the one found by Felfe and Lalive (2010) (0.014 points of a standard deviation), but slightly lower than the one reported by Berlinski et al. (2009) (0.24 points of a standard deviation) for a preschool policy in Argentina.[32] Moreover, we do not find any effect on Math test score. This result may depend on the fact that cognitive skills used in the Language test may benefit more from socialization and from other activities taken up at child care facilities; instead, Math skills seem more linked to innate abilities and may benefit less from the interactions with other children in the first years of life.

We find a positive and significant impact of both paternal and maternal education on children's test scores and that the coefficients are greater for Language than for Math, but they do not differ between parents. As stated in section 2.5, however, we cannot claim a causal impact for the coefficients of these variables. Non-Italian children perform worse than their Italian peers and the test score gaps are higher for Language than for Math. GDP is positively and significantly correlated with both Language and Math test scores. The coefficients for school size and it square are statistically significant for both Language and Math test scores only when province dummies are added to the specification. Pre-primary enrollment rate is statistically significant for both fields when adding province dummies, while the percentage of private primary schools and the percentage of graduates are negatively correlated with the Math test score. Employment rate in public services and the coefficient for employment rate in health and social services are never statistically different from zero.

[32]This difference may be due to timing issues, since Berlinski et al. (2009) measure the effect of the policy on children aged 4 to 5 years. In this study we are considering children aged 7 years, if regular in their school path.

For all the dependent variables, the average effects of a percentage change in child care coverage in the GLS estimation are robust to the inclusion of province dummies. Notice that for both maternal work and Language test score, the estimated coefficients with province fixed effects are higher than the ones obtained from GLS, implying that with GLS we are underestimating the true effects. While this pattern can be due to an attenuation bias induced by measurement error, it may also provide evidence of a negative correlation between provinces' unobservables and the availability of public child care in both equations. In other words, adding the province dummies to the estimation partially solves the selection issue, for which richer and more developed provinces are also those with the higher child care coverage. When we estimate the model using GLS, we do not control for this selection and we find a lower child care effect. According to the theoretical framework proposed in section 2.4, richer provinces can also provide higher child care coverage because they are also characterized by richer demanders, on which they charge an higher price. However, the effect of a percentage change in child care availability on the outcomes of interests in these provinces is very likely to be low. Once this selection is (partially) taken into account, we find that the average effect of a percentage change in child care coverage increases: in this way, we are also taking into account the provinces where child care coverage is lower and where the additional slot plays a role because it is targeted toward people that may benefit more from it.

In section 2.9 we further investigate this issue, looking at non-linear child care effects along the child care coverage distribution.

2.8. Robustness checks

The results that we have just presented are robust to several specification and sensitivity checks. Specifically, we test the robustness of the results on the following dimensions. First, we test whether the characteristics of the municipality where the household resides play a role for the child care effects within the same province. Then, we replicate the estimation of the outcomes equations keeping only the sample used to estimate the participation equation, in order to see whether missing data on family variables are systematically linked with our analysis. Third, we test the robustness of the results cutting the extreme parts of the child care coverage distribution and decreasing the heterogeneity in the sample. Finally, we test whether measurement error affects our results repeating the analysis on the 2008-09 wave of INVALSI data.

Municipality characteristics

As stated in section 2.5, the estimates of the child care impacts presented in section 2.7 can be biased if child care is provided by the social planner responding to households characteristics and preferences. We argue that since the child care policy is provided at municipal level, using provincial level data we are equalizing over different municipalities in the same provinces. However, to further check whether this correlation plays a role in the results we replicate the analysis splitting the sample of children living in the main municipality of each province from those living in rural areas and smaller municipalities. The idea is that, although facing the same level of child care coverage, mothers and children living in different municipalities may respond differently to child care for many reasons. One is that households living in the main municipality of a province may be more willing to

be dual-earners couples and more used to externalize child care activities. Another reason instead may be that children living in the main municipality of a province may have also better school at our disposal or other activities that allow them to be more prepared when they start school. If these conditions are true, we control for these confounding factors separating children living in the main municipality of a province from those living in the rest of the province. Table 2.5 shows the results.

Table 2.5
Robustness check 1. Unobserved heterogeneity at municipal level. Baseline estimation distinguishing between mothers and children living in big and small municipalities.

	BIG MUNICIPALITIES					
	(a) Mother's work		**(b) Language test score**		**(c) Math test score**	
	GLS	Prov.FE	GLS	Prov.FE	GLS	Prov.FE
Child care coverage	0.011***	0.005	0.278***	0.251	0.061	0.202
	(0.003)	(0.003)	(0.100)	(0.163)	(0.089)	(0.135)
Province Dummies		*X*		*X*		*X*
N.Observations	8189	8189	11454	11454	11454	11454
	SMALL MUNICIPALITIES					
	(a) Mother's work		**(b) Language test score**		**(c) Math test score**	
	GLS	Prov.FE	GLS	Prov.FE	GLS	Prov.FE
Child care coverage	0.015***	0.006**	0.163**	0.185	−0.003	−0.118
	(0.002)	(0.003)	(0.072)	(0.124)	(0.065)	(0.103)
Province Dummies		*X*		*X*		*X*
N.Observations	17098	17098	22254	22254	22254	22254

Notes. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level for GLS estimation and robust for heteroskedasticity in column (a). Controls: male, non-Italian, father tertiary education and mother tertiary education, GDP, pre-primary enrollment rate, school size and its square, private primary schools, percentage of graduates, employment rate in public services and employment rate in health-social services. Big municipalities stem for *capoluogo di provincia*, while small municipalities indicate all other municipalities in a province.

Table 2.6
Robustness check 2. Missing values. Score regressions excluding observations with family information missing.

	(a) Language test score		**(b) Math test score**	
	GLS	Prov.FE	GLS	Prov.FE
Child care coverage	0.177***	0.688***	−0.040	0.070
	(0.059)	(0.201)	(0.065)	(0.168)
Province Dummies		*X*		*X*
N.Observations	25287	25287	25287	25287

Notes. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level for GLS estimation. Controls: male, non-Italian, father tertiary education and mother tertiary education, GDP, pre-primary enrollment rate, school size and its square, private primary schools, percentage of graduates, employment rate in public services and employment rate in health-social services, dummies for having child or family information missing.

Notice that the information on child care coverage is still at provincial level, so the coefficients for the two groups still represent the effect of a percentage change in child care coverage in the province. However, the information on whether the child lives in urban or

rural areas allows to see whether some municipal characteristics can bias the estimates. The results shown in table 2.5 confirms that this is not the case, since the coefficients for the child care coverage variable are close to the ones presented in table 2.4, at least for the specification without province dummies.

It is also interesting to note that the effects are quite different between big and small municipalities among the dependent variables considered. In fact, we find that a percentage change in child care coverage yields a greater change in the probability that the mother works for households living in rural areas, while the effect on Language is higher in the main municipality of the province. This result may be due to the different priorities and objectives that characterize the main municipality in a province with respect to the others in the same province. Recalling the distinction in the access criteria, as defined in section 2.3, the difference in the results may depend on the fact that the main municipality of the province may give priority to disadvantaged children, interpreting the service as an educational one. Instead, the smaller municipalities in a province may be more likely to interpret the service as a conciliating policy, giving priority to working mothers.

Missing data on family characteristics

As previously stated, we estimate the participation equation keeping only observations without any family information missing, while we estimate the child cognitive outcomes equations keeping all the sample. The sample size in the two equations turns out to be very different.

Table 2.6 shows the results from the achievement equations keeping only the sample used to estimate the participation equation, i.e. excluding observations with family information missing. The coefficients are very similar to the ones presented in section 2.4, confirming that missing data are not systematically linked with our analysis and do not bias our results. We only find a coefficient for child care coverage in the Language equation that is slightly lower than the one presented in section 2.4.

Additional robustness checks

As stated in section 2.5, the coefficients estimates in our baseline specification represent average effects, for which we average over individuals living in different provinces (i.e., with different level of child care coverage) and over heterogeneous child care effects. In order to decrease the heterogeneity of mothers and children in the sample we repeat the estimation considering subsamples identified through the child care coverage distribution or other individual characteristics of the child.

In table 2.7, panels (a), (b) and (c) we replicate the analysis excluding the extreme part of the distribution of child care coverage. In panel (a) we drop provinces where child care is lower than the 10th percentile (corresponding to 1.16 percent); in panel (b) we drop all provinces in Emilia Romagna region (that is characterized by a very high child care coverage with respect to the rest of Italy) and in panel (c) we drop provinces where child care coverage is higher than the 90th percentile of the distribution (corresponding to 16 percent). Results are confirmed in all cases: only dropping Emilia Romagna the child care impacts on mother's working status and Language test score is slightly higher.

In table 2.7, panel (d) we replicate the analysis keeping only students regular in their school path, that should be aged 7 years.[33] Also in this case, results do not differ from the ones presented before.

Table 2.7
Robustness check 3. Sample heterogeneity in child care coverage and school performances.

	(a) Mother's working status		(b) Language test score		(c) Math test score	
	GLS	Prov.FE	GLS	Prov.FE	GLS	Prov.FE
Panel (a): Sample without provinces with child care coverage lower than 10th percentile						
Child care coverage	0.011***	0.018***	0.169**	0.483***	0.013	−0.069
	(0.002)	(0.004)	(0.069)	(0.109)	(0.063)	(0.089)
N.Observations	22141	22141	29723	29723	29723	29723
Panel (b): Sample without Emilia Romagna region						
Child care coverage	0.014***	0.014***	0.249***	0.463***	0.100	0.263***
	(0.002)	(0.003)	(0.089)	(0.118)	(0.067)	(0.098)
N.Observations	23417	23417	31346	31346	31346	31346
Panel (c): Sample without provinces with child care coverage higher than 90th percentile						
Child care coverage	0.016***	0.014***	0.246***	0.395**	0.086	0.248*
	(0.003)	(0.004)	(0.094)	(0.160)	(0.070)	(0.133)
N.Observations	22961	22961	30593	30593	30593	30593
Panel (d): Sample of regular students						
Child care coverage	0.014***	0.007*	0.193***	0.480***	−0.002	−0.037
	(0.002)	(0.004)	(0.069)	(0.112)	(0.055)	(0.093)
N.Observations	24001	24001	31953	31953	31953	31953

Notes. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level. Controls: male, non-Italian, father tertiary education and mother tertiary education, GDP, pre-primary enrollment rate, school size and its square, private primary schools, percentage of graduates, employment rate in public services and employment rate in health-social services, dummies for having child or family information missing. The 25th percentile of the child care coverage distribution corresponds to 4 percent, while the 90th percentile corresponds to 16 percent. Regular students are those regular in their school path.

Table 2.8
Robustness check for measurement error. Estimates using INVALSI 2008-09 data.

	(a) Mother's working status		(b) Language test score		(c) Math test score	
	GLS	Prov.FE	GLS	Prov.FE	GLS	Prov.FE
Child care coverage	0.010***	0.005*	0.119**	0.283***	−0.001	0.020
	(0.002)	(0.003)	(0.051)	(0.068)	(0.053)	(0.057)
Province Dummies		*X*		*X*		*X*
N.Observations	27673	27673	43073	43073	43073	43073

Notes. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level for GLS estimation and robust for heteroskedasticity in column (a). Controls: male, non-Italian, father tertiary education and mother tertiary education, GDP, pre-primary enrollment rate, school size and its square, private primary schools, percentage of graduates, employment rate in public services and employment rate in health-social services, dummies for having child or family information missing.

Measurement error

The measure of child care coverage that we have at disposal does not exactly correspond to the true child care availability faced by children enrolled in second grade in 2009-10. In fact, the children in our sample would have been aged 0-2 years in 2003-04, one year before the time to which the child care measure refers. This implies that the child care

[33]INVALSI data provide information on whether the child is regular in his school path or held back before or enrolled in higher grade with respect to children with the same age.

availability that we observe is measured with an error and may represent a lower bound of the true child care coverage.

To test whether this discrepancy affects our estimates, we perform a test repeating the estimation of the same model using data from the 2008-09 wave of INVALSI data. Also in this case, we keep only schools and students that sit the test under the supervision of an external inspector. The children in this survey are far from the measure of child care coverage that we have at our disposal, so we expect an higher effect of measurement error in this case.

The results from this test are presented in table 2.8, where we can see that the coefficients for all the dependent variables are slightly lower than the one found using 2009-10 data. However, while this pattern provides evidence of an attenuation bias induced by measurement error, it seems that it does not affect significantly the estimates.[34]

2.9. Non-linearity in child care impacts

In order to test whether the reduced form effect of child care coverage differs across the child care coverage distribution we repeat the baseline analysis using a non-linear specification. Specifically, we estimate the following equations:

$$L_{ipt=7} = \Psi'_{ipt}\beta_0 + \beta_1 N_{pt\in(0,2)} + \beta_2 N^2_{pt\in(0,2)} + \nu_{ipt} \tag{2.8}$$

$$E_{ipt=7} = \Psi'_{ipt}\gamma_0 + \gamma_1 N_{pt\in(0,2)} + \gamma_2 N^2_{pt\in(0,2)} + \phi_{ipt} \tag{2.9}$$

where Ψ_{ipt} represents the vector of individual and provincial characteristics we controlled for in the baseline estimation. We estimate the above equations using GLS and table 2.9 presents the results.

Notice that the relationship between child care coverage and both mother's employment and Language test score has a concave form, being the coefficient for child care coverage positive and the one for the non-linear term negative. This implies that the effect of a percentage change in provincial child care coverage is higher when the availability of the service is scarce, i.e. the service is more rationed. For instance, when child care coverage is only 5 percent, a percentage increase in the availability of the service induces an increase in mother's probability to work by 2 percentage points, while the effect on Language corresponds to 0.42 points. Figure 2.4 further confirms this relationship, showing that a child care coverage equal to 22.68 and 21.13 maximizes the proportion of mothers working and the Language test scores, respectively. The figure does not plot the relationship between child care coverage and Math score, because the coefficients for child care coverage and its square are never statistically significant in the Math score regression.

The non-linear relationship between child care coverage and mother's work and Language score, respectively, implies that the average effect of a percentage change in child care coverage where the coverage is very low, i.e., the service is more rationed, is greater than in areas where child care is more available. This result is in line with the theoretical framework proposed in section 2.4, predicting that when child care availability is low the

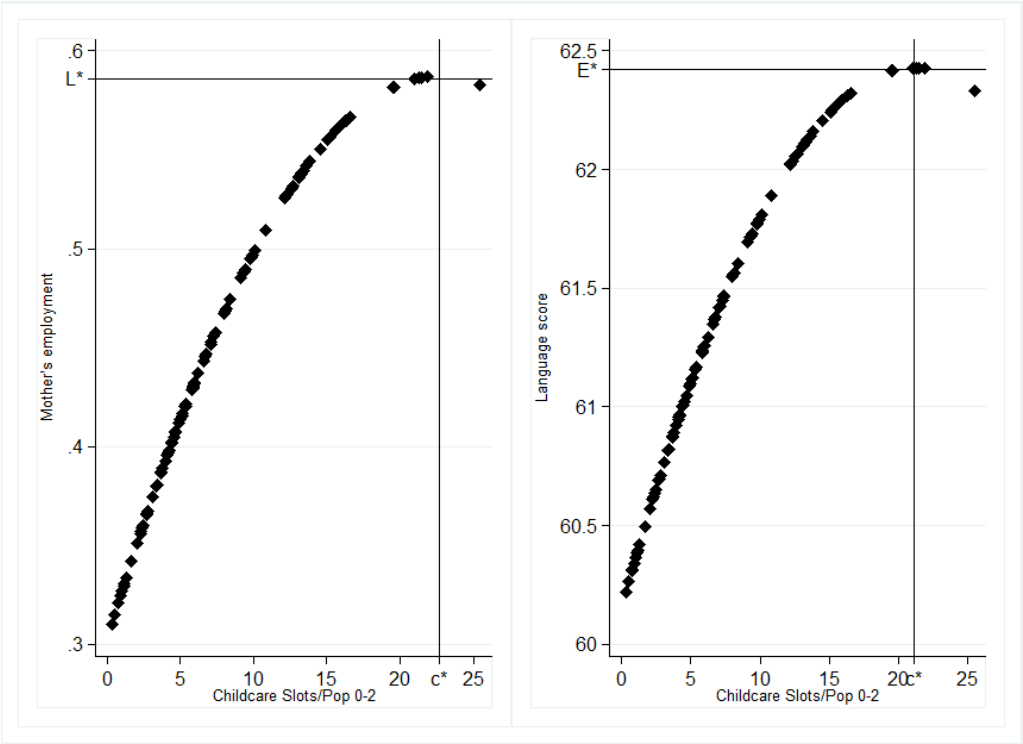
[34]The measure of child care coverage in 2005 represents the true child car faced by children born in 2004 and aged 0-2 in 2005-06. These children have been enrolled in second grade of primary school in school year 2010-11. The INVALSI data referred to this cohort will be available soon, so that we will be able to replicate the analysis without any mismatch in the timing of variables.

Table 2.9
Non-linearity in child care impacts.

	(a) Mother's working status	(b) Language test score	(c) Math test score
Child care coverage	0.028***	0.438**	0.169
	(0.006)	(0.182)	(0.158)
Child care coverage squared	−0.001***	−0.011	−0.008
	(0.000)	(0.008)	(0.007)
N.Observations	25287	33708	33708

Notes. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level and robust for heteroskedasticity in column (a).

Figure 2.4
Non-linear relationship between child care coverage and the outcomes.



Notes. This figure plots the fitted values of the following regressions: $\mathrm{L}_{ipt=7} = \Psi'_{ipt}\beta_0 + \beta_1 N_{pt\in(0,2)} + \beta_2 N^2_{pt\in(0,2)} + \nu_{ipt}$ $\mathrm{E}_{ipt=7} = \Psi'_{ipt}\gamma_0 + \gamma_1 N_{pt\in(0,2)} + \gamma_2 N^2_{pt\in(0,2)} + \phi_{ipt}$ where Ψ is a vector including the following controls: male, non-Italian, father tertiary education and mother tertiary education, GDP, pre-primary enrollment rate, school size and its square, private primary schools, percentage of graduates, employment rate in public services and employment rate in health-social services, dummies for having child or family information missing. N represents child care coverage at the province level. The coefficients estimates for β_i and γ_i, with $i = 1, 2$, are shown in table 2.9. c^* represents the value of child care coverage for which the corresponding outcome is maximized. The child care maximizing outcome is computed setting $\frac{\partial y}{\partial child\ care} = 0$, where y stems for mother's employment status and Language test score: $c^* = 22.678$ for mother's employment and $c^* = 21.1013$ for Language score. $L^* = 0.5837$ is the proportion of women that works when the level of child care coverage c^* is reached. $E^* = 62.3836$ is the score level reached when the level of child care coverage c^* is reached.

local authority mostly uses eligibility requirements to allocate slots, targeting households that may benefit more from it.

Notice that the level of child care coverage for which both the outcomes are maximized, according to the estimates, is much lower than, for instance, the 33 percent target required by the European Union. In order to understand this difference we should keep in mind the different purposes of child care, i.e., custodial and educational. It seems reasonable to think that this policy may have positive effects on the Language abilities of children in a province up to a certain point. Moreover, the corresponding level that we find for

mother's employment may represent a lower bound of the effect on mother's work, due to the timing with which we observe this variable. In fact, should we have observed the participation of mothers immediately after the implementation of the child care policy (i.e., when the child is 3 or 4 years old), we might get a stronger effect, and, consequently, an higher level of child care availability maximizing the outcome.

2.10. Conclusions

In this chapter we estimate the average effect of public child care coverage on mother's working status and children's school performances at primary school. Using INVALSI data for the school year 2009-10, in conjunction with data on child care coverage at province level, we find a positive child care effect on mother's working status as well as on Language test scores. A percentage change in child care coverage yields an increase in the probability that the mother works when the child is in second grade of 0.013, while the effect on Language test score ranges from 1.9 to 4.8 points, corresponding to an average change of 0.8 to 2 percent of a standard deviation. These results are robust to the inclusion of province dummies and to a battery of specification checks.

In exploring the impacts of public child care, it is crucial to take into account the social planner decision-making process. In our theoretical framework the municipalities' decisions regarding the number of child care slots to supply depend on the budget constraint and preferences of the local government, and the social planner may use rationing as a mean to maximize her objective function. Specifically, the social planner's preferences drive her own choices on which type of households to target the service. When the supply of public child care is lower, the social planner may further use access criteria to give priorities to some households instead of others. In this case, the additional slot can be targeted toward families and children who may benefit more from it. For this reason, we expect the relationship between child care coverage and the outcomes to be non-linear and the effects of a percentage change in public child care to be greater when child care coverage is low.

In order to test this idea, we estimate a non-linear specification of the base model, finding that the relationship between child care coverage and mother's work and Language test score is actually concave. When child care availability is low the effect of a percentage change in child care on both mother's working status and Language test score is stronger. Moreover, we find a positive child care effect up to the point where child care availability covers around 21 percent of the population aged 0-2. Notice that this value is lower than the one proposed by the European Union of 33 percent. One plausible explanation for this can be that child care may serve as a custodial tool to help mothers to stay in the labor market, but also as an educational service investing in children's human capital accumulation. Thus, it is important to consider both these functions when estimating the effects of public child care. It may be the case that child care can have a educational role up to a certain point and then being just custodial, i.e. necessary for the mother to stay in the labor market. We argue that having performed a similar analysis exploiting data on mother's working status when the child is younger (e.g., 4 years old), the child care level maximizing the outcomes would have been higher. It is very likely that our estimate

of the average effect of child care on mother's employment after childbirth represents a lower bound.

Despite the limitations of the data, this chapter provides new evidence on the impacts of public child care for a country, such as Italy, characterized by very low female employment rate and poor performances of children at schools, accompanied by (low) public intervention in policies for young children. We show that a percentage change in public child care availability can have positive and significant effects on both maternal employment and cognitive outcomes, for all children and families exposed to that policy. This result may represent an important message for the policy maker, in order to exploit more the potential effects of child care policies.

2.A. Institutional and historical background: the child care policy in Italy

Child care service in Italy has been publicly provided since 1971, when the O.N.M.I organization, that had responsibility for childhood and motherhood assistance, was canceled out.[35] The first law publicly regulating child care services is Law 6 December 1971, N. 1044[36]: this provision represented an initial attempt to implement public and free child care services, stressing its "decentralized" nature. Still today, child care services are managed at municipal level, while regions have the responsibility for defining criteria for building, management and controls of child care structures. In terms of quality regulation, it means that each region defines its own management criteria (in terms of opening time, pupils/teacher ratio, space per child, etc.), but the municipalities can improve the quality standards required at regional level and can decide to offer more strictly regulated services.[37]

After this first intensive state intervention,[38] Italian government has been almost unconcerned about child care service regulation up to 1996. Moreover, according to the division of legislative competences between regions and state, the central government has only the power to determine the essential levels of child care performances and general rules concerning child care services, without any power in terms of management and regulation. The lack of governance at national level has determined a strong differentiation across Italian regions, that, even if already present in 1972, has been exacerbated in the following years.

In order to increase child care availability and to respond to an higher child care demand, Law N. 285/1997[39] established a "National Fund for Early Childhood and Adolescence", aimed to encourage the development of additional services for childhood, with educational and recreational purposes. Actually, Law 285/1997 defined for the first time the educational purpose of child care and allowed also the private and third sector to provide services different from traditional day nursery.[40] The entry of the private sector has determined a differentiation on quality standards provided: private services rely on standards decided at regional levels, while public services should respect quality standards provided by each municipality. For this reason public child care in Italy is recognized as being of a higher quality than the private one.

Starting from 2002, the importance of child care for future development of children has been recognized, especially at national level. The Italian government and, later on,

[35]The O.N.M.I. (*Opera Nazionale Maternità Infanzia*, in Italian) was founded in 1925 (Law N. 2277/1925 and T.U. N. 2316/1931). It was in charge to aid mothers and children during motherhood and infancy and to help disadvantaged people, in particular giving medical assistance. This organization was canceled out by Law N. 628/1975.

[36]"Five-year plan for the establishment of municipal child care services in collaboration with the State", published in G.U. 15 December 1971, n. 316.

[37]See Istituto Degli Innocenti (2006) for regional regulations of child care services before 2005, i.e., the period considered in the analysis; see Istituto Degli Innocenti (2011a) for regional regulations of child care services in 2010.

[38]Among other things, Law 1044/1971 provided special funds for regions and municipalities, in order to build 3,800 child care structures in the period 1972-1976.

[39]Law 28 August 1997, N. 285: "Provisions for the promotion of rights and opportunities for early childhood and adolescence". Published in G.U. 5 September 1997, n. 207.

[40]These are the so-called *additional services*, that are characterized by shorter opening time or are more diversified during the day, with different regulations concerning teachers' training, teacher/pupils ratio and space per child requirements (Istituto Degli Innocenti, 2002, 2009).

the Italian Constitutional Court, recognized that the primary role for child care should be to promote educational and socializing development of children aged less than 3 years (Istituto Degli Innocenti, 2008). Budget Laws 2002 and 2003[41] provided special funds for child care building and managing, both at municipal and at company levels. Anyway, these laws have been defined partially unconstitutional by the Italian Constitutional Court, so that each region decided autonomously legislation and regulation of child care services, enhancing differences across Italy.[42] Only in 2007, Italian Government has defined a three-year plan[43] for the development of an integrated child care system, with the aim of reaching the Lisbon objectives defined by the European Union in 2002.

As shown in table 2.A.1, however, public child care availability is still very limited and covers only a small fraction of children in the age-range 0-2. Moreover, the increase in public child care availability during last years has been due more to an higher supply of day nursery and day-care services, while the growth of the so-called additional services has been very limited. The entry of the private sector did not favorite an equal distribution of child care services across Italy. Instead, private child care structures widespread in different ways across Italian regions and mostly where public child care was already available. In other words, child care services continue to be developed where they are already present, but not where they lack (Istituto Degli Innocenti, 2008). Figures 2.A.1 and 2.A.2 show the absolute number of available slots (multiplied by 100) by type of management (public or private). It should be noted that both day-nursery and additional services from the private sector develop where public facilities are also more widespread. Moreover, it seems that the participation of the private sector is higher in the provision of less-expensive additional services, than in the provision of (more strictly regulated) day-nursery and center-based facilities.

The 2007 plan has been renewed in 2010, providing additional resources to regions for the implementation of additional child care policies. However, financial resources of municipalities have dramatically decreased during last years, so that there has been a growing use of *outsourcing* practices implying the contextual participation of the public and the private sectors. Today, there may be several types of management and supply of the service. Together with forms of supply completely public where the municipality has the unique responsibility on management, personnels and quality standards, there may be other forms where the municipality outsources part of the service to private entities or buys some slots in private facilities. Summing up, it's possible to identify the following types of child care supply and management: (1) public supply of the service with direct management of the municipality (the municipality is both the owner and the provider of the service); (2) a mixed supply, where the municipality outsources parts of the service to the private sector (the municipality can be the owner of the facility and outsources the

[41]Law 28 December 2001, N. 448, published in G.U. 29 December 2001, N. 301 and Law 27 December 2002, N. 289, published in G.U. 31 December 2002, N. 305.

[42]Judgments of Italian Constitutional Court 370/2003 and 320/2004. Budget Laws 2002 and 2003 have been defined unconstitutional in their parts concerning the provision of funds from state to regions, aimed to improve child care availability and to enhance existing child care supply; this state intervention violated the decentralized nature of child care services and the corresponding regional responsibility for their management.

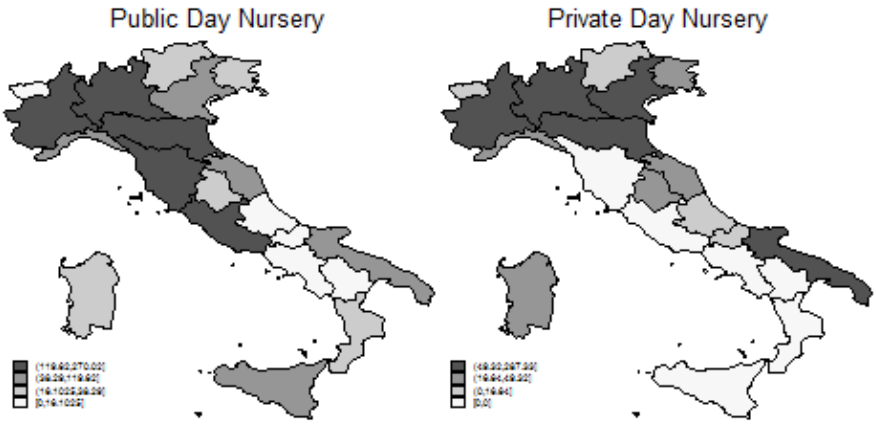
[43]*Piano straordinario per lo sviluppo dei servizi socio-educativi per la prima infanzia*, enacted with Budget Law 2007 (Law 27 December 2006, n. 296) has provided state and local funds, for a total investment in the period 2007-2009 of 727 million Euros (Governo Italiano, 2010).

provision of some services, as cleaning services, or it can just buy some slots in private structures; (3) private supply, where the private sector is the owner and the provider of the service and does not receive any forms of subsidy from the state neither from the municipality. As stated in section 2.6, the child care data used in this analysis refer to the first type of management. At the time to which the analysis is referred (2002-2005), both the second and the third types of supply were almost absent.

Table 2.A.1
Public child care coverage over population 0-2 years in Italy, several years. Source: ISTAT (2011)

	2003-04	2004-05	2005-06	2007-08	2008-09	2009-10
Nursery and Day-care centers	9.0	9.1	9.6	9.9	10.4	11.3
Additional services	2.4	2.1	2.1	2.2	2.3	2.3
All child care services	11.4	11.2	11.7	12.0	12.7	13.6

Figure 2.A.1
Slots in formal child care (per 100) by type of management (public or private), 2010. Own elaborations from Istituto Degli Innocenti (2011b).

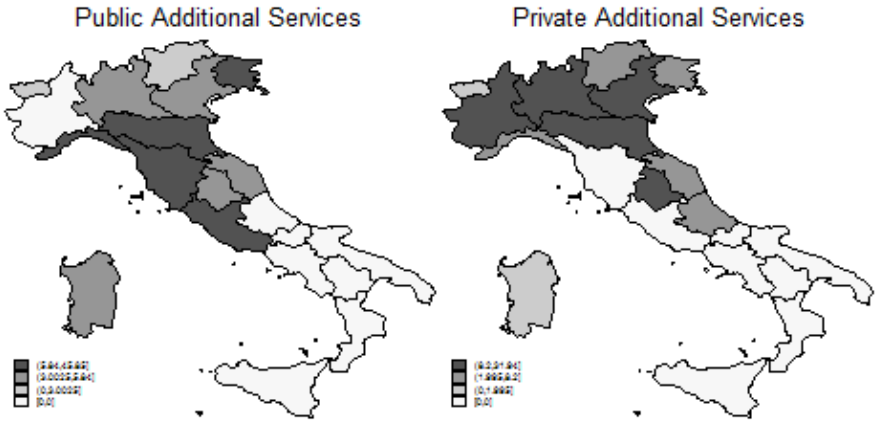


2.B. The INVALSI data

The Italian Institute for the Evaluation of the Education System (INVALSI) have begun a yearly survey of learning achievements both at primary and secondary schools in the 2008-09 school year. Starting from 2008-09, INVALSI and its National Evaluation Service (*Servizio Nazionale di Valutazione* (SNV), in Italian) have assessed students' competencies in Language and Math in second, fifth and sixth grades (ISCED level 1 and 2).

For the first evaluation in 2008-09, INVALSI chose a random sample of primary schools across all Italian regions and allowed not-sampled school to participate voluntarily to the

Figure 2.A.2
Slots in additional services (per 100) by type of management (public or private), 2010. Own elaborations from Istituto Degli Innocenti (2011b).



evaluation. Of the 7,778 total primary schools in Italy, 1,121 were sampled while 4,263 decided to participate voluntarily. The compliance rate has been very high in the random sample (about 95.36%), so that 1,069 schools, of 1,121 sampled, joined the analysis.

The 2009-10 evaluation has been the first imposed to the census of schools (7,700 primary schools and 5,895 secondary schools) and students. Among these schools, INVALSI chose a random sample of classes and students that sit the test under the supervision of an external inspector. Out of the 464 thousands students in second grade, 34,069 of them belong to the sampled schools. The sample represents the 7.33 percent of the overall student population in second grade.

In order to avoid potential biases due to the voluntary decision to participate to the assessment (in the 2008-09 wave) or to the cheating behavior of students and teacher during the test (in the 2009-10 wave), we consider in the analysis only sampled schools, where tests have been conducted under the supervision of an external observer (INVALSI, 2009, 2011).

For second graders, INVALSI defines two assessment tools: a test for Language and a test for Math. Each test is composed by a different number of items (i.e. questions), as shown in the following table. The majority of items are multiple-choices questions.

	2008-09 WAVE		2009-10 WAVE	
Test	Time	Number of Items	Time	Number of Items
Language	30 minutes	34	35 minutes	26
Math	30 minutes	24	30 minutes	22

The Language test includes questions on text comprehension, knowledge of Italian grammar and sentence construction. The Math test include questions which evaluate students' knowledge of mathematical concepts, use of number patterns and their ability to read graphs. These tests have been designed following the experience of the leading international assessments, as IEA-PIRLS and OCSE-PISA.[44] For further details on INVALSI assessment design see INVALSI (2009) and INVALSI (2011).

School administrations provide to INVALSI information on the children's and parents' background characteristics. The school staff is required to provide data on child's gender, birthplace and citizenship, together with information on parents' birthplace, education and occupation, as long as they are available from administrative records.

Table 2.B.1
Probit regression for missing values. Dependent variable: dummy for having any family information missing.

Dep. Var.	**Having any family information missing**
Male	−0.0018
	(0.0159)
Gender missing	−0.3518***
	(0.0654)
Regular	−0.0711
	(0.0451)
Father born in Italy	−0.2676***
	(0.0331)
Father birthplace missing	1.1288***
	(0.0507)
Mother born in Italy	−0.2226***
	(0.0304)
Mother birthplace missing	0.2170***
	(0.0500)
North Italy	0.1074***
	(0.0184)
Central Italy	0.3441***
	(0.0209)
Constant	−0.4647***
	(0.0492)
N.Observations	33708

Notes. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is equal to 1 if information on mother's or father's education or employment is missing. The reference categories are: female, not regular in the school path, father born in abroad, mother born abroad and South Italy.

2.C. Analysis on missing values

As pointed out in Section 6, missing information are a crucial issue in INVALSI data source, especially for data on households characteristics that are gathered by school staff. This point is crucial for us, since one of our outcomes (mother's working status) is taken from these variables. In order to understand this point, it should be noted that school

[44]The programme IEA (International Association for the evaluation of Educational Achievemment) and PIRLS (Progress in International Reading Literacy Study) provides international assessments of fourth grade students in reading, while the programme OCSE-PISA (Programme for International Student Assessment) evaluates 15-years-old students across OECD countries in reading, sciences and Math competencies.

personnels are responsible for providing personal child and family information to INVALSI officers. When these data are not available on school records, school staff should survey them directly from child's parents. In our opinion, the existence of this mass of missing data is due to the fact that school staff does not contact parents in order to gather missing information.

In order to further analyze this issue and to see whether missing values are systematically linked with our analysis, we construct a dependent variable equal to 1 if any of the parents' education and work variables are missing and we perform a probit regression using this dummy as dependent variable. Results are shown in table 2.B.1.

The coefficient estimates confirm our thought that the staff of several schools simply do not gather any information on parents, when they are not available on administrative records. In fact, children with missing information on citizenship, regularity and parents' birthplace are more likely to have missing information on parents' education and occupation, together with children whose father was born abroad. It should be noted, however, that regional macro-area dummies are always significant and that children living in the central and northern parts of Italy are more likely to lack information on parents' education and occupation.

CHAPTER 3

Mother or market care? A structural estimation of child care impacts on child development

ABSTRACT - This chapter analyzes the effects of maternal employment and external child care on child development, taking into account the additional choice the mother makes between leisure and time with the child. I propose and estimate a behavioral model where labor supply, external child care and leisure time allocation are endogenously chosen by the mother and represent the inputs for the child cognitive development. The model is estimated using U.S. data from the Child Development Supplement (CDS) of the Panel Study of Income Dynamics (PSID) and the Time Diary (TD) component of the CDS. Results show that a reduction in maternal time with the child induces a negative effect on child's ability, that is compensated for by the use of external child care for the same amount of time. This implies that maternal employment is not detrimental for child development. The estimated model is used to perform a counterfactual exercise, where the mother spends all the time out of work with the child without having leisure: this shows that previous literature has overestimated the productivity of maternal time and the negative effect of maternal employment on child development.

JEL classification: D13, J13, J22.

Keywords: non-parental child care, mother time allocation, mother employment, child development, structural estimation.

3.1. Introduction

During the last decades, there has been a growing research on the determinants of child cognitive achievement. Not only psychologists but also economists agree that one of the most valuable inputs for child's development is the time the child spends with the mother (Cunha et al., 2006). Indeed, the increase in maternal employment rate and the use of external forms of child care have raised concerns about the impacts that they may have on child's development. In the U.S., the participation rate of married women increased from around 40 percent in the 1970s to more than 60 percent at the end of the 1990s. Moreover, almost 65 percent of children aged 3-5 were enrolled in nursery schools before kindergarten during the 1990s (U.S. Census Bureau, 2000). The majority of children of employed mothers regularly spend time in some forms of non-school non-parental care, so that the use of non-parental child care continues when the child reaches primary school age (Blau and Currie, 2006).

The psychological literature argues that maternal employment and external child care may determine insecure mother-child attachments, which are formed in the first years of a child's life (Varin, 2007). However, Brooks-Gunn, Han, and Waldfogel (2002) posit that maternal employment may not necessarily have a negative effect on child development, since employed mothers provide a more stimulating environment to their child than the non-working ones do. The economic literature on these topics is large, but findings are mixed and very few studies adopt a credible identification strategy. Moreover, a research that evaluate the effects of maternal employment and non-parental child care taking into account the actual time spent by the mother with the child is lacking.

The identification of the impacts of both maternal employment and external child care on child's development is hampered by three main sources of endogeneity. The first is due to the selection of mothers into employment and external child care use, induced by the correlation between mothers' choices and their unobservable skills. For instance, more skilled mothers may be more likely to work and to use external child care. If their skills are transmitted to their child in a way that the researcher cannot control for, this may overestimate the true effect of external child care. The second source of endogeneity depends on the correlation between mother's decisions and child's ability that the mother can (partially) observe, while the researcher does not. Finally, unobserved heterogeneity of both mothers and children is more difficult to take into account due to the simultaneity of these choices.

Most of the studies use Ordinary Least Square to evaluate the effect of maternal employment and external child care, but they are very likely to fail in taking into account these sources of endogeneity. Other identification strategies that have been adopted in the literature to account for these issues encompass Mother or Siblings fixed effects and Instrumental Variables estimators. While the former allows to get rid of time invariant unobserved heterogeneity of the mothers, the consistency of the latter relies on the assumption that the mothers react to the instruments without taking into account child's ability.

An alternative approach that has not yet been extensively used in this literature is structural estimation. This is the only strategy allowing to model different sources of endogeneity and, most importantly, to describe the decision making process of the mother

for more than one endogenous choice. Moreover, it provides parameters estimates from theoretical model that can be used to simulate the effects of related policies.

Despite there being several studies in the child development literature using this approach, only Bernal (2008) applies this framework to the maternal employment and child care case. Moreover, a study that estimates these impacts taking into account the actual time spent by the mother with the child is lacking. In fact, both Bernal (2008) and all other studies using a reduced-form approach assume a specific relationship between maternal employment time and the time the mother spends with the child (Keane, 2010). More precisely, they estimate a cognitive ability production function with maternal employment as an input, arguing that the time the mother spends with the child can be proxied by the total amount of time available to the mother net of the time she spends at work. This definition of maternal time implies that the mother dedicates to the child all the remaining time out of work and that she does not care about having leisure. The most common finding of these studies is that maternal employment and external child care have a substantially negative effect on child's ability.

However, this assumption is very likely to fail if the mother decides how to allocate the time out of work between leisure and care of the child. Moreover, the time allocation may substantially differ across employment status, since non-working mothers have more time out of work at disposal. For instance, Bianchi (2000) suggests that employed mothers allocate their time in such a way to give priority to the time they spend with the child. Hoffert and Sandberg (2001) show that there is not a one-to-one corresponding relationship between the time the mother spends out of work and the time she actually spends with the child.

In this chapter, I propose and estimate a behavioral model where the labor supply, non-parental child care and time allocation choices of the mother are endogenous. The model describes the mother's decisions to work, to use external child care and to spend time with the child starting from childbirth up to age 13. The model allows a direct estimation of the impact of maternal time on child's development, accounting for the fact that the mother not only chooses how many hours to work and how much external child care to use, but also how much time to devote to the child instead of having more leisure. The mother's utility maximization problem is subject to the mother's time and budget constraints, as well as the child cognitive ability production function: the mother cares about consumption, leisure and the child's cognitive ability, while child's ability is specified with a value-added functional form and depends on the inputs received in the previous period. The empirical specification of the model introduces several sources of heterogeneity: the mother's preference parameters depend on mother's observable characteristics, while the mother's unobserved skills affect the taste for child's ability, the participation to the labor market, the demand for non-parental child care and the choice between leisure and time with the child; finally, the child's initial endowment, i.e., the child's level of ability at birth, depends on both mother's and father's education, capturing a non-zero correlation between child's skills and parents' educational attainments.

The model is estimated using U.S. data from the Panel Study of Income Dynamics (PSID) and the Child Development Supplement (CDS) conducted in 1997, 2002 and 2007. The CDS provides retrospective information on all child care arrangements used since birth

and widely-recognized measures of child's cognitive outcomes; the Time Diary (TD) section provides unique data on the amount of time the child spends with the mother. The main PSID surveys give detailed information on mother's work history and household income during the child's life cycle. The parameters of the model are estimated using a Simulated Minimum Distance (SMD) estimator that minimizes the distance between several data statistics and their model counterparts.

The main contribution of this study is to estimate the effect of maternal time and external child care relaxing the assumption that mother time out of work is a good proxy for maternal time with the child. In fact, differently from all existing studies using reduced-form approaches and from Bernal (2008), this chapter takes into account the additional (endogenous) choice of the mother between leisure time to spend alone and time to spend with the child. Second, it represents the first attempt to estimate the elasticity of child's ability with respect to both maternal time and external child care time in a child cognitive production function framework. To the best of my knowledge, there are not studies that simultaneously evaluate the productivity of both inputs.[1]

The results show that more skilled mothers have higher preferences for child's ability. This implies that, even if they work more, they also make higher investments on their child's cognitive ability, either spending more time with the child or choosing more external child care or both. The estimated parameters in the child's cognitive ability production function show that, for an equal amount of maternal time and external child care time, the marginal productivity of maternal time is slightly lower than the one of external child care. Hence, if the mother works, a reduction in child's ability induced by a reduction in maternal time can be fully compensated for if the child spends the same amount of time in external child care. The model performs quite well in predicting the child's score distribution and the distribution of wage and income in the data.

In a counterfactual exercise, I re-estimate the model assuming leisure-minimizing preferences of the mother: the mother does not care about leisure and spends all the time out of work with the child. The results show that, in this case, a reduction in maternal time due to mother's work induces a reduction in child's ability that is not compensated for by the use of external child care. In other words, the final effect of mother's employment is clearly negative. Indeed, this result exactly replicates what has been mostly found before in the literature. Hence, previous studies, defining maternal time as a residual from maternal working time, have overestimated maternal time productivity and the negative effect of maternal employment.

The estimated model is used to simulate the (local) effects of policies improving the economic conditions of the household or decreasing the price of the service. The results show that policies aimed at boosting mothers employment may have controversial effects on child's development. Hence, the policy maker should take this into account when implementing such interventions.

The rest of the chapter is organized as follows. Section 3.2 provides a background of the literature and presents some stylized facts in external child care use and maternal time allocation. Section 3.3 presents the model that is estimated: subsection 3.3.1 defines the

[1]Recently Del Boca et al. (2012) and Hsin (2009) have exploited PSID-CDS data to assess the effects of several time inputs on child development, one of them being maternal time. However, they do not consider the productivity of external child care time.

basic structure, while subsection 3.3.2 discusses how the model is solved and presents the demand functions for all the choice variables. Section 3.4 presents the econometric specification of the model (subsection 3.4.1) and the empirical method used for the estimation (subsection 3.4.2). Section 3.5 describes the data, while section 3.6 presents the results and discusses the goodness of fit of the model (subsection 3.6.1). Section 3.7.2 presents the results from the counterfactual exercises and section 3.8 concludes.

3.2. Background

The increase in female employment rate that has characterized all developed countries has raised concerns for the impacts that maternal employment and external child care may have on child development. This is one of the reasons why, in the last decades, many studies try to assess the effects of these choices.

Starting with Becker and Tomes (1986), who first provide a framework for the implications of household decisions for children's subsequent utility and earnings, there has been a growing literature on the impacts of parental investments on children human capital and development. However, the studies on maternal employment and external child care present mixed findings. Several reduced-form studies find negative effects of maternal employment (Baydar and Brooks-Gunn, 1991, Belsky and Eggebeen, 1991, Chase-Lansdale et al., 1989, Ruhm, 2004), while others find null effects (Chase-Lansdale et al., 2003, James-Burdumy, 2005, Parcel and Menaghan, 1994). Also studies on non-parental child care using reduced-form strategies provide ambiguous results. Bernal and Keane (2011) report that one year of child care use decreases children's cognitive outcomes, measured by the PIAT and PPVT scores, by 2.13 percent. Currie and Thomas (1995, 1999), instead, evaluate the impacts of the early childhood program Head Start and find that children who attend the program get higher scores at PIAT reading and Math test. Similarly, Magnuson et al. (2007) find positive effects of having attended pre-kindergarten on academic achievement at kindergarten and primary school. The majority of studies just considers the use of non-parental care, without taking into account the intensity of the treatment. Just a few consider the impacts of the length of time spent in non-parental care. Loeb et al. (2007) find that staying in center-based child care for more than 15 hours per week increases reading and Math score by almost 8 and 7 percent of a standard deviation.

The identification of the effects of both mother's employment and external child care choices on child's development is hampered by their correlation with both mother's and children's skills, as well as by their simultaneity. While studies using OLS are very likely to fail in taking into account these sources of endogeneity, there are studies using other techniques to handle these issues. Currie and Thomas (1995, 1999) use Mother fixed effects to control for time invariant unobserved heterogeneity of the mother, while Bernal and Keane (2011) use an Instrumental Variables estimator to take into account the correlation between the mother's choices and the child's ability. While the first strategy is robust to the correlation of the mother's decisions with mother's skills that do not vary over time, the second provides consistent estimates of the effects of interests only if it can be assumed that the mother reacts to the instruments without taking into account child's ability.

Structural estimation allows to account for the sources of endogeneity that may arise in this context, modeling the mother's decision making process for different choice variables.

In this framework, each input is optimally chosen by the mother who maximizes her own utility function, with child's ability as an argument, and the child's ability production function is one of the constraints to this maximization problem. There are few studies using structural estimation in the child development literature. The model presented in this chapter builds on Del Boca et al. (2010), who estimate the impacts of parents' time inputs on children's development. They model household choices and investments in child quality from childbirth up to the last developmental period, when the child reaches adolescence. They define a dynamic discrete-time model where, in each period, both parents decide how many hours to work, how much time to spend with the child and the amount of expenditure on the child. In the definition of the choice variables, they distinguish between active and passive time of the mother, i.e., if the mother is directly involved in the child's activities or she is just around without participating. They estimate that the elasticity of child ability with respect to maternal active time ranges from 0.25 when the child is two years old to 0.05 when he reaches 15 years of age; indeed, they find a very small elasticity for maternal passive time.

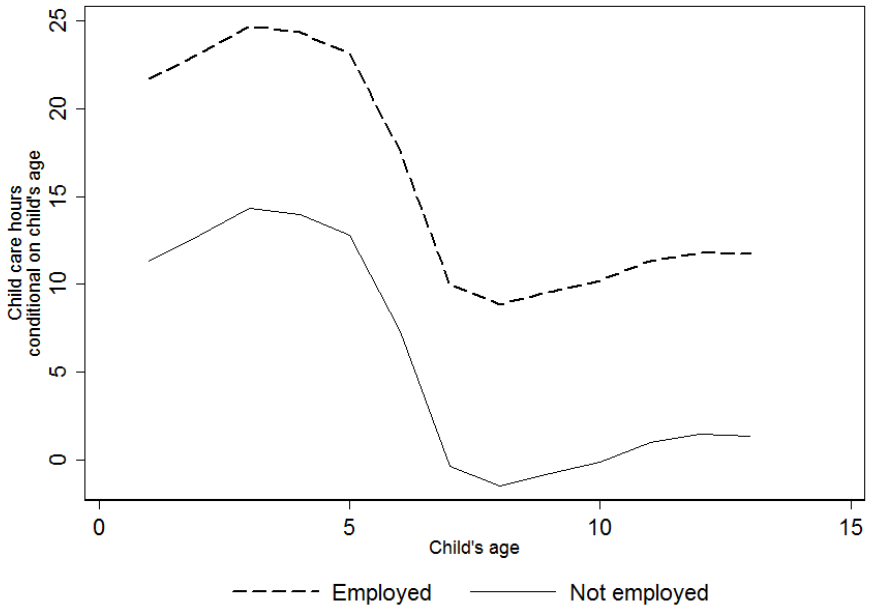
Mroz et al. (2010) specify and estimate a behavioral model of household migration and maternal employment decisions in order to assess the effect of these choices on child's cognitive ability proxied by the PIAT Math score. In assessing the effects of maternal employment on subsequent child outcome, they also consider the household migration decisions, which can be induced by better labor market opportunities but also by better school characteristics, which the parents may value for their child's development. They find that part-time employment of the mother reduces the child's score by 3 percent of a standard deviation while the mother's full-time status reduces the score by 5 percent of a standard deviation.

Bernal (2008) is the only study that evaluates the impact of maternal employment and external child care attendance on subsequent child outcomes using a structural approach.[2] She defines a single agent discrete-time multi-period model, where the mother decides among different combinations of work and child care use. The choice variables are discrete and the dichotomous variable for using child care is defined as being equal to one if the child ever used (in each period) any form of non-parental care. Bernal's main contribution is to consider the impact of the work and child care choices in the first five years of life of the child and to test whether the mother decides to work and to use external child care after having observed the child's initial ability endowment. Bernal (2008) finds that one year in external child care reduces the child's cognitive ability by 0.8 percent; however, the impact of mother's employment and external child care is even more detrimental, as it decreases child's outcome by 1.8 percent.

The substantially negative effects found in these studies (Bernal, 2008, Mroz et al., 2010) may depend on the assumption they make concerning the relationship between maternal time with the child and mother's time at work. In fact, it is generally assumed a one-to-one relationship between mother's time out of work and maternal child care time. Actually, this has implications for the effect that is estimated. Since this assumption

[2]Bernal and Keane (2010) propose a quasi-structural estimation: their identification strategy builds on a model very similar to Bernal (2008), applicable to only one-child families, and they estimate it using a sample of households with more than one child controlling for the number of children in the household. It is quasi-structural in the sense that the estimation does not completely rely on the theoretical model proposed.

Figure 3.1
Non-parental child care time by mother's employment status.



NOTES. The vertical axis represents the fitted values of the following regression:

$$childcare_i = \eta_0 + \eta_1 t_i + \eta_2 d_i + \epsilon_i$$

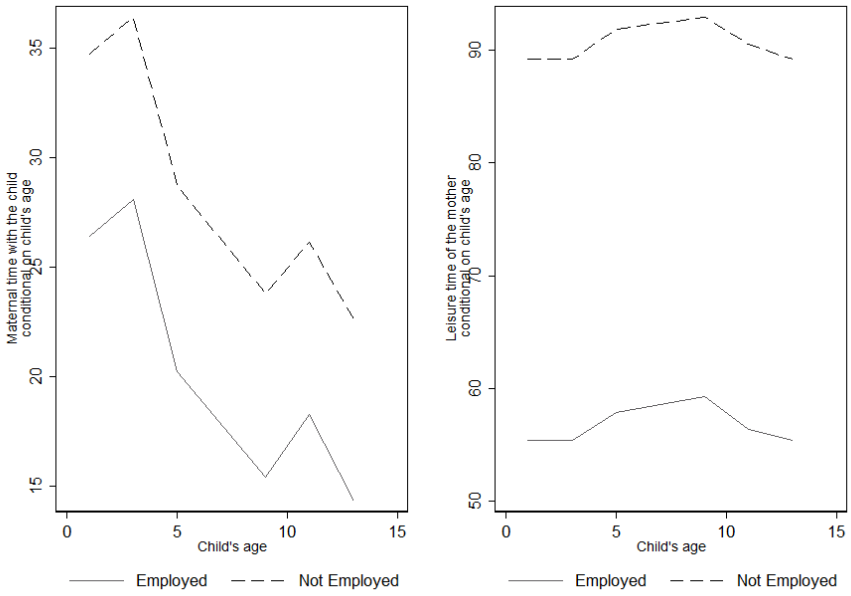
where $childcare_i$ represents (weekly) hours of external child care, t_i are child's age fixed effects, d_i is a dummy variable equal to 1 if the mother of child i works. $\eta_2 = 10.36$ represents the difference in average child care use (conditional on child's age) between working and non-working mothers. Source: own elaboration from PSID-CDS data ($N = 3510$).

implies that all the time the mother spends out of work represents an investment in the child's ability, and employed mothers spend less time at home, this turns out to estimate a negative effect of mother's work due to the reduction in maternal time. However, this assumption may not hold if mothers decide how to allocate their time out of work between leisure and time with the child. Neglecting this additional choice may lead to overestimate the amount of time the mother spends with the child and, also, its productivity.

Even though data on mothers' and children's time use have become available only very recently, there have been some studies suggesting that mothers do not differ only in terms of participation decisions but also in terms of leisure time allocation. Leibowitz (1974, 1977) points out that more skilled and more educated mothers may also have a higher propensity to stay with their child, even if working. Recent studies on mothers' time use confirm this point, since they do not find significant differences across employment status in the amount of time mothers spend with their child (Bianchi, 2000, Hoffert and Sandberg, 2001).

The absence of significant differences in maternal time with the child between working and non-working mothers can be attributed to two main reasons. On the one hand, during recent years, also non-working mothers have started using external child care, so that children of non-working mothers may also not be always available for maternal investments while attending external child care. For instance, Bianchi (2000) shows that from the end of the 1960s to the end of the 1990s, the percentage of 3-5 children enrolled in some forms of pre-primary educational programs increased from 7.9 to 51.7 for mothers

Figure 3.2
Maternal child care time and leisure by mother's employment status.



NOTES. The vertical axis in the graph on the left represents the fitted values of the following regression:

$$\tau_i = \eta_0 + \eta_1 t_i + \eta_2 d_i + \epsilon_i$$

while the vertical axis in the graph on the right represents the fitted values of the following regression:

$$l_i = \beta_0 + \beta_1 t_i + \beta_2 d_i + \varepsilon_i$$

τ stems for (weekly) maternal time with the child and l represents leisure time, computed as $l = TT - \tau - h$ where $TT = 112$ is the total time endowment and h represents weekly hours of work. t_i are child's age fixed effects and d_i is a dummy variable equal to 1 if the mother of child i works. $\eta_2 = -8.32$ represents the difference in average maternal time (conditional on child's age) between working and non-working mothers. $\beta_2 = -33.72$ represents the difference in average leisure time (conditional on child's age) between working and non-working mothers. Source: own elaboration from PSID-CDS data ($N = 624$).

in the labor force and from 4.8 to 44 percent for mothers not in the labor force. Blau and Currie (2006) report that this trend is confirmed for school-age children, who regularly spend time in some forms of after-school programs. On the other hand, working and non-working mothers may allocate their time out of work differently, so that the actual time that they spend with the child does not correspond to the time they spend out of work.

Descriptive evidence from the PSID-CDS data used in this chapter supports the existence of these patterns. Figure 3.1 shows that also non-working mothers use a positive amount of external child care for their child. This may happen if, for instance, they value the educational role of the service and choose it as an investment in their child's human capital. However, since the difference in average child care time between working and non-working mothers is equal to 10.36, the graph also confirms that child care is needed for its custodial purposes anytime the mother is working.

Figure 3.2 plots the fitted values of two regressions where the dependent variables are, respectively, maternal time with the child and leisure time. The graph on the left confirms that employed mothers allocate their time out of work in order to spend a positive amount of time with their child. Conversely, non-working mothers do not spend all their time with the child, but only around 30 hours per week when the child is very young and around 25 when the child grows up. The graph on the right shows the fitted values of a regression

on child's age fixed effects where the dependent variable is leisure time, computed as the difference between the total time endowment and the sum between working time and time with the child. Employed mothers spend a very low amount of time out of work in leisure, while the corresponding level for non-working mothers is considerably higher. Notice that while the difference in maternal time with the child between working and non-working mothers is equal to 8 hours per week, the difference in leisure is equal to 33 hours per week.

3.3. The model

This section describes the theoretical model on which the estimation is based. Subsection 3.3.1 presents the basic structure of the model, while subsection 3.3.2 derives the demand functions for all the choice variables.

3.3.1. Basic structure. The model follows a standard framework from Becker and Tomes (1986), where household preferences are described by a unitary utility function, with child's ability as an argument, and subject to a production function for child's ability plus budget and time constraints.[3] The functional form assumptions are based on the theoretical model developed in Del Boca et al. (2010).

As in Bernal (2008) and Del Boca et al. (2010), the model applies to intact households, where both the mother and the father are present. Moreover, I consider only households with one child and, following Bernal (2008), I assume that the mother is the unique decision maker in the household concerning the work and external child care use decisions. This assumption implies that father's labor supply is exogenous with respect to child development[4] and that the father does not bargain with the mother concerning the external child care choice. However, the model allows the father to affect child development in two ways: the child's ability endowment depends also on father's education; father's labor income contributes to household earnings that are an input in the child cognitive production function and influence mother's choices concerning work, external child care and time with the child. Finally, the simplification concerning the number of children allows to avoid modeling the fertility decisions of parents and to make additional assumptions on the different effects of investments on more siblings.[5]

The model is dynamic and evolves in discrete time. In each period, the mother decides her own labor supply and time allocation, as well as the amount of external child care to use. The choice variables are then: (i) h_t, representing hours of work; (ii) i_t, hours of external child care and (iii) τ_t, the time the mother spends with the child. The timing is defined as follows: $t = 0$ represents the birth of the child and the mother makes all the decisions (in a relevant way for the child's development process) at each child's age t

[3]As pointed out by Blau (1999b), the basic elements of any economic theory for the effect of an input on child development "are (i) a utility function that contains child outcomes as arguments; (ii) a production function for the child outcomes with inputs including the time of family members and purchased goods and services; (iii) budget and time constraints; and (iv) a specification of the information structure and the formation of expectations."

[4]Actually, this assumption mostly follows from the characteristics of the sample of intact households that I see in the data. In fact, all fathers in the sample work and the average working time does not change across child's age or across mother's participation decisions.

[5]As pointed out by Bernal (2008), "In a model with multiple children, one would also have to specify how total maternal contact time is allocated among children and take a stand on the extent to which maternal time is a public good."

until the child reaches T years of age; $t = 1$ indicates the first 12 months of the child's life, $t = 2$ refers to the next 12 months of the child's life, and so on and so forth; $t = T$ represents the terminal period of the model. One may interpret this terminal period as the final of a specific developmental stage of the child, so that starting from this period both the mother's utility maximization problem and the child's cognitive production function change.[6]

The Mother's Utility Function

Mother's utility in each period is a function of her own leisure time (l_t), i.e, the time the mother spends alone without working, household consumption (c_t), including father's and child's consumption, and the child's cognitive ability (A_t). I assume a Cobb-Douglas form for preferences and I restrict the preferences parameters to be stable over time:

$$u(l_t, c_t, A_t) = \alpha_1 lnl_t + \alpha_2 lnc_t + \alpha_3 lnA_t \tag{3.1}$$

where $\sum_{j=1}^{3} \alpha_j = 1$ and $\alpha_j > 0$, $j = 1, 2, 3$.

The mother maximizes her utility subject to the budget and the time constraints. The budget constraint takes into account household consumption and the total income available in the family (from both parents' labor supply and non labor income) and is given by:

$$c_t = w_t h_t + I_t - pi_t \tag{3.2}$$

where w_t is mother's hourly wage; I_t represents household earnings (including father's labor income and household non labor income); i_t represents the number of hours that the mother uses non-parental child care and p is the hourly price of child care. The variable i_t includes any kind of non-parental child care arrangement. Finally, the mother does not make saving or borrowing decisions, hence household income defined by I_t can be considered as exogenous with respect to all mother's choices.

The time constraint takes into account both the leisure time the mother spends alone and the time the mother devotes to the child:

$$TT = l_t + h_t + \tau_t \tag{3.3}$$

where TT is the mother's total time endowment,[7] h_t is the number of hours the mother works and τ_t is the number of hours the mother spends with the child. Notice that, in each period, the mother can choose to spend her leisure time alone (l_t) or to devote some time to the child (τ_t): hence, the model allows the mother to further choose between leisure and time with the child when she is not at work.

[6] $T = 13$. It may be interpreted as the final period of middle childhood before the child enters adolescence. The definition of the terminal period theoretically implies that after T mother's investments do not have any impact on child development. According to table 3.E.1, controlling for the choice variables, the child's age at which the cognitive test score is maximized is equal to 11.92. As a robustness check, I repeat the estimation of the model setting $T = 12$. Results are shown in appendix 3.E.1.

[7] $TT = 112$ hours per week: it assumes 16 hours per day, that the mother should allocate between working, leisure and time with the child (see, for instance, Del Boca and Flinn (2012)). All choice variables are defined on a weekly basis.

The Child's Cognitive Ability Production Function

The child's cognitive ability production function (hereafter CAPF) is defined using a value-added specification and taking a Cobb-Douglas form:

$$lnA_{t+1} = \delta_{1t} ln\tau_t + \delta_{2t} lni_t + \delta_{3t} lnI_t + \delta_{4t} lnA_t \tag{3.4}$$

where A_{t+1} is the outcome for a child at time $t+1$, τ_t and i_t are the inputs decided by the mother in each period t; I_t represents the income of the household, as already defined, and A_t is the level of child ability at period t. Since current ability influences future child's ability, equation (3.4) shows that inputs operate with a lag: development takes time. Moreover, the structure of equation (3.4) implies that when deciding the inputs on child development, the mother knows the productivity of each of them and the level of child's ability in the previous period.[8]

Despite posing some limitations on the substitution pattern across inputs due to the assumed functional form, the model allows the parameters in (3.4) to vary across child's ages in order to capture the fact that marginal productivity of inputs varies over the stages of child development (Cunha, Heckman, and Schennach, 2010, Heckman, 2007).

Mother's work is not explicitly included in the CAPF, because it may not have a direct impact on child development *per se*. Mother's employment may indirectly affect child development through the change in the mother's time allocation, together with the use of non-parental child care. The child care input includes all contributions to child development due to the alternative care providers' time and may be more or less productive than mother's own time. This specification allows to test whether, in each period, maternal time is more productive than external child care time. If this is the case, then, for any period and for an equal amount of maternal time and child care time used, $\delta_{1t} \geq \delta_{2t}$.[9]

While the amount of non-parental child care can represent a measure of the services bought for the child, the household income in (3.4) proxies the expenditure in goods for the child (Todd and Wolpin, 2003). The use of I_t as a proxy for the goods bought for the child relies on two assumptions: (i) a constant proportion of income is devoted to buy goods effective for child development and (ii) this proportion is not affected by the mother's labor supply decisions.[10] Furthermore, income can have a direct impact *per se* as long as it captures the economic conditions where the household resides (Blau, 1999b, Levy and Duncan, 2012).

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[8]This implies that the estimated parameters in the CAPF are robust to the mother deciding her investments after having observed the child's level of ability. As pointed out by Keane (2010), "assumptions on what the mother knows are essential if the econometrician is to solve the mother's dynamic optimization problem". While assuming that the mother knows more about the child's ability production function than the econometrician does can be reasonable, it may be unrealistic to assume that the mother has complete information. However, the mother can learn about the productivity of each input and the child's ability after some realizations. This chapter does not model this learning mechanism, simplifying to the mother's complete information case. See Fogli and Veldkamp (2011) or Fernandez (2007) for a model where the mother is uncertain about the effect of her employment on child's development and chooses her labor market participation according to the available information set.

[9]For any period t, the marginal productivity of maternal time is given by $MP_{\tau_t} = \frac{\delta_{1t}}{\tau_t}$, while the marginal productivity of external child care is $MP_{i_t} = \frac{\delta_{2t}}{i_t}$. For $\tau_t = i_t$, $MP_{\tau_t} \geq MP_{i_t}$ if $\delta_{1t} \geq \delta_{2t}$; viceversa, $MP_{\tau_t} \leq MP_{i_t}$ if $\delta_{1t} \leq \delta_{2t}$.

[10]The model implies that the additional labor income the mother gets from her labor supply is spent in external child care.

Concerning the amount of external child care used by the child, the model does not distinguish between different kinds of service (for instance, formal vs. informal arrangements). Hence, it is assuming that all types of care have the same impact on child development and that the mother's decision making process for the two types of care is similar. The same homogeneity is then reflected in the price of external child care. The model predicts a strictly positive price of the service, regardless of its nature. This implies that also services with a potentially zero price in the market are characterized by a shadow price, representing, for instance, the limited availability of informal care or the value of the unpaid care provider's time in alternative activities (Blau and Currie, 2006, Ribar, 1992).

The CAPF defined in (3.4) provides consistent estimates of the productivity parameters for each input if the following conditions hold: (i) A_t is a sufficient statistics for the inputs history received by the child in the previous periods; (ii) the child's initial endowment (that the mother observes but the researcher does not) is only reflected in the level of ability in the first period and does not affect subsequent ability (Todd and Wolpin, 2003).

Maximization Problem

In each period, the mother receives a wage offer. The wage offer is assumed to be exogenously determined in each period and to be uncorrelated with labor supply and wages in the previous periods.[11]

Given the wage offer and the level of child cognitive ability in each period, the mother maximizes her expected life time utility, optimally choosing her labor supply, the child care input and the number of hours to devote to the child.

The value function for the mother at period t is given by:

$$V_t(S_t) = max_{h_t,i_t,\tau_t} \; u(l_t, c_t, A_t) + \beta E_t V_{t+1}(S_{t+1}) \tag{3.5}$$

$$s.t. \;\; c_t = w_t h_t + I_t - p i_t$$

$$TT = l_t + h_t + \tau_t$$

$$lnA_{t+1} = \delta_{1t} ln\tau_t + \delta_{2t} lni_t + \delta_{3t} lnI_t + \delta_{4t} lnA_t$$

where $\beta \in [0,1]$ and $S_t = \{A_t, w_t\}$ represents the vector of state variables. The child's cognitive ability represents an endogenous state variable, while the wage offer the mother receives in each period is exogenous with respect to the maximization problem but differs for each mother in each period. The initial condition of the problem is given by the value of the state variables in the first period.[12]

[11]The structure of this wage offer will be defined in subsection 3.4.1. The fact that the wage process is exogenous with respect to the mother's working decisions in any period implies that the offer the mother receives in period t is not affected by her working decisions in $t-1$ and that it does not reflect any depreciation in mother's productivity due to the absence from the labor market after childbirth. If the wage process were defined so to depend on previous labor supply choices, the model would become intractable and could not be estimated using continuous choice variables and closed form solutions. Notice that the use of continuous choice variables is necessary to allow for three choices and to take into account the additional choice between leisure and time with the child, that is the main contribution of this work.

[12]The timing of the model implies that after childbirth and during the first 12 months of child's life the mother observes the initial level of child's ability and receives a wage offer; then she makes her decisions. Similarly, in the following periods, the mother chooses h_t, i_t and τ_t after having observed the corresponding level of A_t and after having received the wage offer from the labor market. The structure of the initial condition for child's ability will be defined in subsection 3.4.1.

3.3.2. Terminal period value function and solution of the model. The problem defined by equation (3.5) can be re-written as:

$$Max_{\{h_t,i_t,\tau_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(l_t, c_t, A_t) \tag{3.6}$$
$$s.t.\ S_t = \{A_t, w_t\} \in \Omega_t$$

where Ω_t represents the state space in each period t. The solutions to this maximization problem involves three sequences of values.

The mother makes work, child care and time allocation decisions (that are relevant for the child development process described by equation (3.4)) in the first T years of the child's life. After period T, both the mother's optimization problem and the child's ability production function change: the mother may continue to optimally choose labor supply and consumption, but she will not longer consider maternal and external child care choices.

The terminal level of child's cognitive ability is A_{T+1}, i.e., the level of ability reached in $T+1$, that will not be affected by subsequent mother's decisions. Thus, $A_t = A_{T+1}$ for any period $t = T+1, T+2, \ldots, \infty$. This level of ability may be interpreted as the starting point for future child's development during adolescence, from $T+1$ on.

The period $T+1$ maximization problem for an infinitely-lived household may be written as:

$$V_{T+1} = \tilde{V}_{T+1} + \sum_{\kappa=0}^{+\infty} \beta^{\kappa} \alpha_3 lnA_{T+1} \tag{3.7}$$

where

$$\tilde{V}_{T+1} = max_{h_{T+1}}\ \alpha_1 lnl_{T+1} + \alpha_2 lnc_{T+1} + \beta E_{T+1} \tilde{V}_{T+2}(l_{T+2}, c_{T+2})$$

and $\sum_{\kappa=0}^{+\infty} \beta^{\kappa} = \rho$ represents the value given by the mother to child's ability in the last developmental period.[13] Equation (3.7) represents the terminal period value function[14] and implies that the mother's maximization problem after period T does not depend on t and on the choices made in the previous period. Starting from period $T+1$, the mother decides only how much to work and, in each period, this choice affects only her current utility, without affecting the utility and decision-making process in the following periods.

The model is solved by backward induction and yields closed-form solutions for all the choice variables. The solution of the model involves the computation of the value function starting from the terminal period and the corresponding optimal solutions in each period. Following a two-stage process, I first derive the optimal solutions for external child care (i_t) and maternal time (τ_t), conditional on h_t, and then I compute the solutions for the mother's labor supply h_t. Analytical derivations of the results are in appendix 3.A.

The demands for child care and time with the child, conditional on mother's labor supply, in each period, are given by:

$$i_t^c = \frac{\beta \delta_{2t} D_{t+1}}{p(\alpha_2 + \beta \delta_{2t} D_{t+1})}(w_t h_t + I_t) \tag{3.8}$$

$$\tau_t^c = \frac{\beta \delta_{1t} D_{t+1}}{(\alpha_1 + \beta \delta_{1t} D_{t+1})}(TT - h_t) \tag{3.9}$$

[13] In the estimation, the discount factor is set at $\beta = 0.95$. In order to increase the flexibility of the model and to allow the discount factor of the mother to differ in the last period of investments with respect to the previous ones, the parameter ρ is estimated.

[14] The terminal period value function is similar to the one assumed in Del Boca et al. (2010).

where $D_{t+1} = \frac{\partial V_{t+1}}{\partial ln A_{t+1}}$ represents the marginal utility the mother gets from child's future cognitive ability, in each period. The sequence of marginal utilities from period $T+1$ to period 1 is given by:[15]

$$\begin{aligned} D_{T+1} &= \rho\alpha_3 \\ D_T &= \alpha_3 + \beta\delta_{4T} D_{T+1} \\ D_{T-1} &= \alpha_3 + \beta\delta_{4T-1} D_T \\ &\vdots \\ D_t &= \alpha_3 + \beta\delta_{4t} D_{t+1} \\ &\vdots \\ D_2 &= \alpha_3 + \beta\delta_{42} D_3 \\ D_1 &= \alpha_3 + \beta\delta_{41} D_2 \end{aligned} \tag{3.10}$$

An implication of the Cobb-Douglas specification used in the mother's utility function and in the child cognitive ability production function is that any input should be strictly positive.[16] However, I do allow the possibility of corner solutions for the mother's labor supply decisions.

The mother's latent labor supply, conditional on i_t^c and τ_t^c, is given by:

$$h_t^c = \frac{\alpha_2(TT - \tau_t^c)}{\alpha_1 + \alpha_2} - \frac{\alpha_1(I_t - pi_t^c)}{w_t(\alpha_1 + \alpha_2)} \tag{3.11}$$

Substituting (3.8) and (3.9) in equation (3.11), the latent labor supply becomes:

$$h_t^* = \frac{TT(\alpha_2 + \beta\delta_{2t} D_{t+1})}{(\alpha_1 + \beta\delta_{1t} D_{t+1} + \alpha_2 + \beta\delta_{2t} D_{t+1})} - \frac{I_t(\alpha_1 + \beta\delta_{1t} D_{t+1})}{w_t(\alpha_1 + \beta\delta_{1t} D_{t+1} + \alpha_2 + \beta\delta_{2t} D_{t+1})} \tag{3.12}$$

The actual labor supply in each period is determined according to the following rule:

$$h_t = \begin{cases} h_t^* & \text{if} \quad h_t^* > 0 \\ 0 & \text{if} \quad h_t^* \leq 0 \end{cases}$$

According to equation (3.12), the mother's latent labor supply is negative or zero only if household income is strictly positive and sufficiently high. The reservation wage of the mother, i.e. the wage offer for which the mother is indifferent between working and not working, is given by the following expression:[17]

$$w_t^* = \frac{I_t}{TT} \frac{(\alpha_1 + \beta\delta_{1t} D_{t+1})}{(\alpha_2 + \beta\delta_{2t} D_{t+1})} \tag{3.13}$$

Notice that the reservation wage of the mother is a function of both the preference parameters in the utility function and the productivity parameters in the child cognitive ability production function. The mother's reservation wage is higher if the mother cares more about leisure or if the coefficient for mother's time in the CAPF is higher ($\frac{\partial w_t^*}{\partial \alpha_1} > 0$ and

[15] The same expressions can be derived computing $D_{t+1} = \frac{\partial V_{t+1}}{\partial A_{t+1}}$ instead of $D_{t+1} = \frac{\partial V_{t+1}}{\partial ln A_{t+1}}$ (See appendix 3.A, footnote 35). Notice that the marginal utility in $T+1$ is discounted for all the subsequent periods in which child's ability does not depend on mother's investments decisions.

[16] Concerning the child cognitive ability production function, if any factor is set at zero, the child ability is zero in all subsequent periods (since if $A_{t-1} = 0$, then for any t, $A_t = 0$) and the mother's utility will approach $-\infty$ as $A \to 0$, even if $\alpha_3 > 0$ (Del Boca et al., 2010).

[17] This expression is derived making $h_t^* = 0$ and solving for w_t.

$\frac{\partial w_t^*}{\partial \delta_{1t}} > 0$); instead, the reservation wage decreases if the mother cares more about consumption or if the coefficient for non-parental child care in the CAPF is higher ($\frac{\partial w_t^*}{\partial \alpha_2} < 0$ and $\frac{\partial w_t^*}{\partial \delta_{2t}} < 0$).

Substituting (3.12) into (3.8) and (3.9) yields the unconditional demands for child care and time with the child:

$$i_t^* = \frac{\beta\delta_{2t}D_{t+1}}{p(\alpha_2+\beta\delta_{2t}D_{t+1})} I_t \left[1 - \frac{(\alpha_1+\beta\delta_{1t}D_{t+1})}{\alpha_1+\beta\delta_{1t}D_{t+1}+\alpha_2+\beta\delta_{2t}D_{t+1}}\right] + \tag{3.14}$$
$$+ \left(\frac{w_t}{p}\right) \frac{TT\beta\delta_{2t}D_{t+1}}{\alpha_1+\beta\delta_{1t}D_{t+1}+\alpha_2+\beta\delta_{2t}D_{t+1}}$$

$$\tau_t^* = \left[TT - \frac{TT(\alpha_2+\beta\delta_{2t}D_{t+1})}{\alpha_1+\beta\delta_{1t}D_{t+1}+\alpha_2+\beta\delta_{2t}D_{t+1}} + \left(\frac{I_t}{w_t}\right) \frac{(\alpha_1+\beta\delta_{1t}D_{t+1})}{(\alpha_1+\beta\delta_{1t}D_{t+1}+\alpha_2+\beta\delta_{2t}D_{t+1})}\right] \times \tag{3.15}$$
$$\times \frac{\beta\delta_{1t}D_{t+1}}{(\alpha_1+\beta\delta_{1t}D_{t+1})}$$

Notice from equation (3.14) that demand for child care can be driven by necessity of custodial care, i.e., if the mother is working and needs someone looking after the child, or by valuing the educational role of the service. In fact, non-working mothers (for which $h_t = 0$) can demand of it if they value child's ability and they think child care can represent an input for child's development, as long as household income is strictly positive. The data generating process (DGP) defined by the model always predicts a positive amount of external child care, regardless of mother's working status. Instead, equation (3.15) shows that the demand for time with the child is decreasing in wage, that is the opportunity cost of maternal time in the labor market ($\frac{\partial \tau_t^*}{\partial w_t} < 0$).

3.4. Econometric strategy

Structural estimation involves assumptions on how observed and unobserved heterogeneity enters the model described in the previous section. Section 3.4.1 presents the empirical specification used to take the model to the data, taking into account the available information at my disposal. Subsection 3.4.2 describes the econometric method used to estimate the model parameters. Further details on the empirical analysis performed to estimate the model are in appendix 3.B.

3.4.1. Empirical specification. Unobserved and observed heterogeneity enters any stage of the decision-making process of the mother described in the previous section.

Consider first the utility function, where the parameters represent the tastes of the mother for leisure, consumption and child's ability. I allow observed and unobserved heterogeneity in preferences, defining these parameters as functions of some observed and unobserved characteristics. Specifically,

$$\alpha_1 = f_1(MotherEdu, MotherRace, \gamma_1, \Gamma_2, \Gamma_3, \mu_0)$$
$$\alpha_2 = f_2(MotherEdu, MotherRace, \gamma_1, \Gamma_2, \Gamma_3, \mu_0)$$
$$\alpha_3 = f_3(MotherEdu, MotherRace, \gamma_1, \Gamma_2, \Gamma_3, \mu_0)$$

where $\gamma_1 = 0$, $\Gamma_2 = (\gamma_{2\ MotherEdu}, \gamma_{2\ MotherRace})$ and $\Gamma_3 = (\gamma_{3\ MotherEdu}, \gamma_{3\ MotherRace})$ are vector of parameters representing the contribution of each observable characteristic to the corresponding preference parameter. The functional forms for f_1, f_2, f_3 are specified in appendix 3.B.1. μ_0 represents mother's skills, that are assumed to be distributed with a multinomial density and to take on two values representing two types of mothers: μ_{0high} represents the high-skilled type, while μ_{0low} is the low-skilled type. The values μ_{0high}, μ_{0low} and the probability that the mother belongs to each type (π_{mh} and $\pi_{ml} = 1 - \pi_{mh}$) are parameters to be estimated.[18] This specification allows the parameters in the mother's utility function to vary across subgroups in the sample[19]. Notice that observationally equivalent mothers can still have different preferences according to their skills.

As stated in section 3.3, in each period, the mother receives a wage offer and decides whether to enter in the labor market comparing the value of this offer with her reservation wage. The offer the mother receives is described by the following wage equation:

$$ln(w_t) = \mu_t + \epsilon_t \tag{3.16}$$

where

$$\epsilon_t \overset{\text{iid}}{\sim} N(0, \sigma_\epsilon^2)$$

is assumed to be uncorrelated over time and represents a transitory shock on wage that the mother can observe. The term μ_t is the mean of the log wage draws of the mother at time t and it is defined as follows:

$$\mu_t = \mu_0 + \mu_1 educ + \mu_2 age_t + \mu_3 age_t^2 + \mu_4 race \tag{3.17}$$

where μ_0 represents mother's skills, as already defined. Equation (3.17) states that the offer the mother receives from the market depends on her skills, her education and experience (captured by the age component and its square), but also on her race.

As for the wage process, also the income process is exogenous with respect to the mother's inputs decisions in each period. The evolution of the household income reflects the following structure:

$$I_t \overset{\text{iid}}{\sim} N(\mu_{inc}, \sigma_{inc}^2) \tag{3.18}$$

where μ_{inc}, σ_{inc} are parameters to be estimated.

Concerning the child's cognitive ability production function, as stated in section 3.3.1, the parameters can vary across child's age. In order to respect the parameterization implied by the Cobb-Douglas functional form, the coefficients in equation (3.4) must be strictly positive; thus, they are defined as follows:

$$\delta_i = exp(\xi_i t) \tag{3.19}$$

where $i = 1, 2, 3, 4$ and t represents the age of the child.[20]

[18] See appendix 3.B.1 for the specification of the parameters in the utility function and for the mother's type proportions.

[19] Each group is defined by the combination of mother's years of education and race. Mother's years of education range from 2 to 17, while race is a dummy variable equal to 1 if the mother is white.

[20] Allowing the parameters to vary across child's age partially compensates for the lack of substitutability implied by the Cobb-Douglas functional form used to define the CAPF. Moreover, it allows to capture the (potentially) decreasing productivities of the inputs considered in (3.4): when the child reaches primary school age, other (unobserved) school inputs can contribute to his own cognitive development and family investments have lower influence.

In order to estimate the model and to take into account the dynamic optimization problem faced by the mother, one needs to know the starting level of ability, i.e., the child's cognitive ability the mother observes in the first period before making her investments decisions. The initial ability endowment is assumed to be specified as follows:

$$A_1 = exp(\psi_{ck} + \eta_1 MotherEdu + \eta_2 FatherEdu) \tag{3.20}$$

where ψ_{ck} represents child's skills, that are distributed with a multinomial density:

$$f(\psi_{ck}) = P_k$$

with $P_k \geq 0$ and $\sum_k P_k = 1$. ψ_c can take on two values ($k = h, l$), representing high and low skilled children. As for the mother's types, the values ψ_{ch} and ψ_{cl} should be estimated, together with their corresponding probabilities π_{ck} $k = h, l$. The inclusion of mother's and father's education allows to capture a non-zero correlation between these observable characteristics and child's skills. Moreover, as suggested by Bernal and Keane (2010), using as much observables as possible in the definition of (3.20) should reduce the sensitivity of the results to the distributional assumptions on the unobserved heterogeneity term.[21]

Finally, it should be described how the true child's cognitive ability is related to the measure of that given by the test scores. Existing studies using a structural approach (Bernal, 2008, Bernal and Keane, 2010) define the test score measure as a continuous variable and identify a linear relationship between this variable and the child's cognitive ability, including a disturbance term. This notation interprets the test scores as a proxy for the true child's ability, but it does not take into account the fact that these measures represent just the number of questions answered correctly by the child. Following the approach suggested by Del Boca et al. (2010) and based on classical test theory (Novick, 1966), I define the probability that the child answers correctly to each item as a function of the true child's ability:

$$\pi_{score} = \frac{exp(A_t + v_t)}{1 + exp(A_t + v_t)} \tag{3.21}$$

where $v_t \overset{\text{iid}}{\sim} N(0, \sigma_v^2)$ represents measurement error capturing the fact that test scores depict true child's ability with a noise. The structure of (3.21) ensures this represents a value between zero and one. The test score measure is then defined as follows:

$$S_t = \pi_{score} * J_t \tag{3.22}$$

where J_t is the maximum number of items answered correctly at each child's age.[22]

Summing up, the empirical specification of the model allows the mother's preference parameters to depend on mother's observable characteristics and unobserved ability, while mothers with higher skills receive, on average, higher wage offer, are more likely to work

[21] Due to the structure of the available data, the identification of more parameters in the child's initial endowment is hampered by the scarcity of test score observations for each child. In fact, at most, I can observe 2 test score measures for each child and the test score measure is available only for children aged more than 4. In appendix 3.E.4 I report the results of a robustness check where the child's initial endowment depends also on birth weight but all children are assumed to have the same level of skills.

[22] The score measure used in the empirical analysis is the Letter Word test. To define the thresholds J_t I use the overall PSID-CDS data (3243 observations) and I identify the maximum number of items answered correctly at each age: in the age range 4-5 $J = 30$, in the age-range 6-8 $J = 50$ and finally, for $t = 9, 10, 11, 12, 13$ $J = 57$.

and to use more external child care. Moreover, observationally equivalent mothers can receive different wage offers over time because of the transitory shock on wage that the mother can observe but the researcher does not. Finally, the definition of the child's initial endowment as a function of parents' education captures a non-zero correlation between parents' cognitive abilities and child's skills.

3.4.2. Estimation method. The model parameters are estimated using a Simulated Minimum Distance (SMD) estimator that minimizes the distance between a large number of data statistics and their model counterparts. The statistics used to construct the moment functions are summarized in table 3.1.

The simulation of the data generating process (DGP) implied by the model accounts for the selection of mother's participation in the labor market and the endogeneity issues arising for all the other choice variables. In other words, the DGP models the selection mechanisms underlying the work, external child care and time decisions. This point has practical consequences, in that it allows to recover non-randomly missing information, as mother's wage. In fact, when the information on mother's employment status is available in the data and the mother is not working, mother's wage is missing in an endogenous way. The simulation of the wage offer that each mother receives in every period allows to describe the participation decision as a function of the preference and productivity parameters.

Further, simulation is needed because the statistics and the moment functions recovered from the model are not in a tractable form. The minimum distance estimator involves the minimization of the distance between statistics provided by the data and statistics that are functions of structural parameters. For instance, define m as the data points and statistics and $M(\theta)$ as the functions of the parameters to be estimated. If the functions are not in an easily computable form, as in this case, they can be substituted with a simulator estimator $\hat{M}(\theta)$ for $M(\theta)$ (McFadden, 1989, Pakes and Pollard, 1989).

The simulation of the data is obtained by taking $N * R$[23] random draws from the initial distribution implied by the model, i.e., the child's and mother's skills distributions, and, for each period, from the wage and income distributions and from the distribution of the error in the test score measure. The time invariant preference parameters were assigned to each mother, according to her observable characteristics and skills, while the productivity parameters were updated in each period. After having drawn the child's ability and the wage offer in the first period, the optimal choices of the mother were obtained, exploiting the optimal solutions derived in section 3.3.2. This process has been repeated for every period, up to the final one T. The simulated data are used to compute the same statistics defined in table 3.1. Both actual and simulated statistics have been used to construct the objective function to be minimized.

The Simulated Minimum Distance (SMD) estimator is then:

$$\hat{\theta} = arg\ min\ \hat{g}(\theta)' W \hat{g}(\theta) \tag{3.23}$$

[23] $N = 434$ and $R = 5$. While R does not affect the consistency of the estimator, an higher number of simulation draws, with N fixed, can decrease the simulation noise and the variance, improving efficiency. However, I decide not to use more simulation draws, because the estimation is already time consuming. Using a laptop computer with Intel i7/1.5 GHz processor and Matlab Version 7.13, the estimating time is about 4 hours.

Table 3.1
Statistics of actual and simulated data used for the estimation of the model.

Inputs and outcome conditional on child's age
mean and std deviation of mother's hours of work
mean and std deviation of child care hours
mean and std deviation of maternal time with the child
proportion of mothers working
average test score
Inputs statistics
mean and std deviation of mother's wage
mean, std deviation and median of household income
corr mother's wage and mother's hours of work
corr mother's wage and household income
corr mother's hours of work and household income
corr mother's hours of work and time with the child
corr mother's hours of work and child care hours
corr household income and time with the child
corr household income and child care hours
Inputs and outcome correlation across time
corr maternal time with the child in 1997 and score in 2002
corr maternal time with the child in 2002 and score in 2007
corr child care hours in t and score in $t+1$
corr mother's hours of work in t and score in $t+1$
corr household income in t and score in $t+1$
Inputs conditional on parents' characteristics
mean mother's wage by mother's education, age and race
mean mother's hours of work by mother's education, age and race
mean maternal time with the child by mother's education, age and race
mean child care hours by mother's education, age and race
Outcome conditional on parents' characteristics
average test score by parents' education
Outcomes transition probabilities (for children with 2 scores measures)
prop of children with score in range p_{97} in 1997 and p_{02} in 2002
prop of children with score in range p_{02} in 2002 and p_{07} in 2007

NOTES. These statistics are computed using PSID-CDS data on children aged 0-12 in 1997, with at least one test score measure and without siblings, and simulated data according to the model defined in section 3.3 and 3.4.1. Maternal time with the child is measured in 1997 and 2002; child's scores are measured in 1997, 2002 and 2007; from 1997 on, mother's hours of work, mother's wage and household income are measured every two years and these variables refer to the year before the survey (see section 3.5 and appendix 3.C for a description of the data). Household income includes both father labor income and household non labor income. Child's age t ranges from 1 to 13. Mother's and father's education are classified as "college" (more than 12 years of education) and "high-school" (12 years of education); mother's race can be white or not white; mother's age is divided in two categories: more than 40 years old and younger than 30. Ranges p_y, with $y = 1997, 2002, 2007$ are defined according to the following ranges of the score distribution: $1st - 25th$ perc, $25th - 50th$ perc, $50th - 75th$ perc, $75th - 95th$ perc, higher than $95th$ perc. 82 observations have test score measures in 1997 and 2002; 99 observations have score measures in 2002 and 2007.

where

$$\hat{g}(\theta) = \hat{m} - \hat{M}(\theta) \tag{3.24}$$

$\hat{m}$ is the vector of statistics defined from the actual data, while $\hat{M}(\theta)$ is the vector of simulated statistics according to the model. Given S number of moments, the weighting matrix is defined as:

$$W = \begin{pmatrix} \hat{V}[\hat{m}_1]^{-1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \hat{V}[\hat{m}_S]^{-1} \end{pmatrix}$$

where $\hat{V}[\hat{m}]$ is estimated with non-parametric bootstrap.[24]

The SMD estimator consistently estimate the model parameters if the following conditions hold: (i) the estimated moments from the data are consistent estimates of the population moments; (ii) the model is identified, a necessary condition for which is that the number of moments is higher than the number of parameters to be estimated ($S \geq K$);[25] (iii) the model is correct: $m_0 = M(\theta_0)$, i.e., the population moments correspond to the simulated moments at the true parameters vector.

Identification of the model parameters requires a unique solution for the minimization of the objective function defined by (3.23). In practice, it depends on the uniqueness of the minimum and on the curvature around it. I estimate the model parameters using different starting values and results do not differ from the ones presented in the following section. Moreover, I check that the objective function changes moving the values of the parameters and I find the value of the objective function to vary around the estimated parameters.

3.5. Data

The model is estimated using data from the Panel Study of Income Dynamics (PSID) and its Child Development Supplement (CDS).

The PSID is a longitudinal study that begun in 1968 with a nationally representative sample of over 18,000 individuals living in 5,000 families in the United States. Starting from 1968, information about each family member is collected, but much greater detail is obtained about the head and the spouse. From 1997, the Child Development Supplement (CDS) gathers information on children aged 0-12 in PSID families through extensive interviews with their primary caregiver. The CDS has been replicated in 2002 and 2007 for children in this cohort who remain under 18.

For this analysis, I exploit the child cognitive ability measures and non-parental child care data provided in the Primary Caregiver Interview of the CDS, together with the time use details given in the Time Diary (TD) component of the CDS. The main PSID surveys are exploited to recover information on mother's work and household income.

The CDS supplement provides several measures of child cognitive skills, based on the Woodcock Johnson Achievement Test Revised (WJ-R) (Woodcock and Johnson, 1989). The outcome measure considered in this study is the Letter Word (LW) test, which is applied to all children older than 4 and proves child's learning and reading skills (Hoffert, Davis-Kean, Davis, and Finkelstein, 1997). The raw LW score represents the sum of correct answers out of 57 items, ranging then from 0 to 57. This measure is available in 1997, 2002 and 2007.

The CDS I (1997 wave) asks to the primary caregiver information on all child care arrangements used for the child since childbirth; a set of following-up questions is asked to the primary caregiver in the 2002 wave of the same supplement. Using both waves, I can recover the complete child care history for the children interviewed in 1997. The variable of interests is the number of hours the child uses non-parental child care at each age. This

[24] See appendix 3.B.2 for further details on the estimation.

[25] To estimate 26 parameters, I use 103 moments conditions.

variable refers to any type of child care arrangement, either formal or informal, provided by people different from parents.[26]

In 1997 and 2002, the Child Development Supplement includes another instrument to assess the time use of children. The Time Diary (TD) is a unique feature of the CDS and consists in a chronological report filled by the child or by the child's primary caregiver about the child's activities over a specified 24-hour period.[27] Each participating child completed two time diaries: a weekday (Monday-Friday) and a weekend day (Sunday or Saturday).[28] The TD additionally collects information on the social context of the activity by specifying with whom the child was doing the activity and who else was present but not engaged. The variable weekly time with the mother is constructed by multiplying the daily hours the child spends with the mother by 5 for the weekday and by 2 for the weekend day, and summing up the total hours in a week.[29]

I take information on mothers and fathers linking the CDS data to the main PSID surveys. Since children in 1997 have different ages, ranging from 0 to 13 years old, in order to identify the necessary information for all children in any period defined by the model, CDS data should be matched with family information from PSID surveys in the years 1985-2007.[30] The family information I gather includes each parent's hours of work, wage and non labor income in each period.[31]

Finally, I construct all relevant variables for each child's age, defining age 1 as the first 12 months of child's life, age 2 as the next 12 months of the child's life, and so on.

For the estimation of the model I consider all children without siblings interviewed in CDS I, living in intact households (where both mother and father are present), without

[26]The CDS questionnaire allows the primary caregiver to indicate more than one arrangement used at each child's age. If the primary caregiver used simultaneously more than one arrangement in a period, I define the child care variables exploiting the information on the arrangement used more hours per week. Notice that, in this case, the corresponding number of child care hours is very likely to represent a lower bound of the true child care use.

[27]The primary caregiver completed the time diary for the very young children (e.g., younger than 3), while older children and adolescents were expected to complete the time diaries themselves (ISR, 2010a,b).

[28]These days were randomly selected when the interviewer completed the initial contact for the household and there was no substitution of diary days once they were assigned to the CDS child (ISR, 2010a,b).

[29]More precisely, the TD distinguishes between contexts where the person with the child is directly involved in the activity ("active time") and others where the person is just around and not involved in the activity ("passive time"). The following time categories can be derived: (1) the child is with the mother, being the mother either involved in the activity or just around; (2) the child is with the mother, who is directly involved in the activity, but the father is around; (3) the child is with the father only; (4) the child is with the father and the mother is around; (5) the child is neither with the mother nor with the father. The analysis has been performed defining the variable weekly time with the mother using only category (1), so that all remaining time spells indicate that the child is not receiving investments from the mother. In order to see whether the results are sensible to this specification, I re-estimate the model using different definitions of maternal time. Results are reported in appendix 3.E.2.

[30]For instance, to identify household information for all relevant periods for a child born in 1996 (1 year old in 1997) I need to use PSID surveys from 1997 to 2007; instead, if a child is born in 1986 (aged 11 years in 1997) I need to use PSID surveys from 1987 to 1999. Basically, all PSID surveys in the period 1985-2007 have been exploited. See appendix 3.C, tables 3.C.1 and 3.C.2.

[31]Between 1985 and 1997 PSID interviews were conducted annually and, since then, interviews have been biennial. Note that all the variables that I use from the main PSID surveys concerning labor and non labor income of the household members refer to the year before the survey. All monetary variables are deflated into 1997 US$ using the Consumer Price Index (CPI) History for the U.S. See appendix 3.C for further description of the data sources used for the analysis.

Table 3.2
Descriptive statistics on all variables for the entire period.

	Mean	SD	Min	Max
Child's LW raw score	35.10	(14.47)	0	57
Mother's hours of work	27.12	(17.55)	0	100
Proportion of working mothers	0.80	0.39	0	1
Non-parental child care hours	14.68	(18.32)	0	70
Mother's time with child	21.06	(17.01)	0.17	95.75
Child's gender: male	0.51	(0.50)	0	1
Mother's wage	14.25	(10.19)	5.01	133.93
Mother's age at child's birth	28.17	(5.10)	16	43
Mother's education	13.25	(2.50)	2	17
Mother's race: white	0.61	(0.49)	0	1
Father's hours of work	45.22	(10.95)	0.06	109.85
Father's wage	19.51	(12.96)	5.01	143.40
Father's age at child's birth	30.28	(6.11)	17	67
Father's education	13.27	(2.49)	1	17
Household non labor income	12.79	(49.10)	0	924.45

NOTES. Monetary variables deflated into 1997 US$. Source: own elaboration from PSID-CDS data.

missing data on personal and parents' demographic characteristics and with at least one test score measure. The final sample is composed by 434 observations.[32]

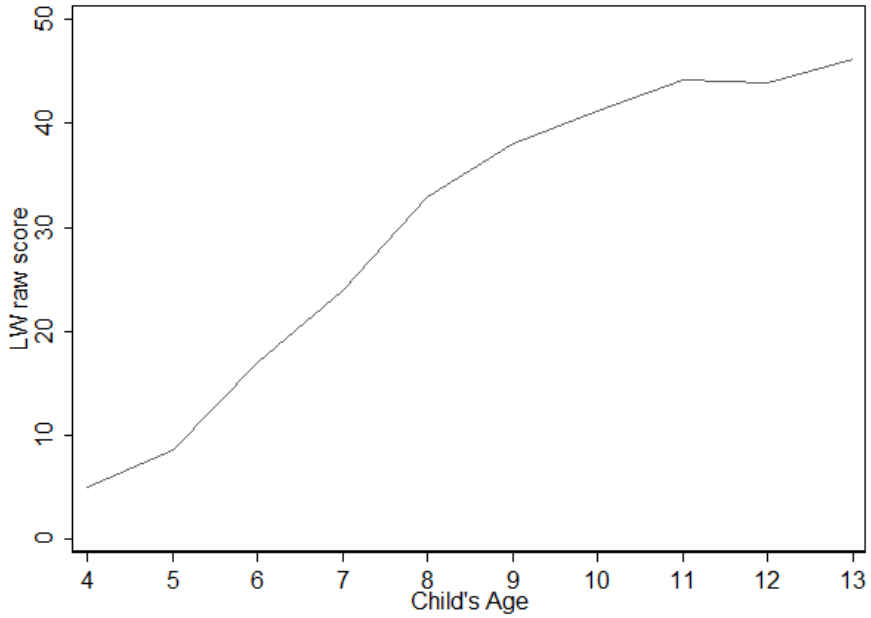
3.5.1. Descriptive Statistics. This section provides some descriptive statistics on the sample used for the estimation.

Table 3.2 shows the average values of all the variables for the period considered in the model. In the sample, the average raw score is around 35 out of 57. Figure 3.3 shows the distribution of the average test score measure by child's age, while appendix 3.D provides further descriptive statistics on the cognitive outcome measure. Mothers work, on average, 27 hours per week and use non-parental child care for almost 15 hours; moreover, they spend with their child, on average, 3 hours per day. Mother's wages are significantly lower than their male counterparts (on average 14.25 US$ versus 19.51 US$), and mothers work less than fathers. Household non labor income represents, on average, around 13 US$ per week.

Table 3.3 provides some descriptive statistics on mother's work, child care and maternal time, by child's age. The temporal pattern of these variables is also reported in figure 3.4. There are not significant differences in mother's participation to the labor market across child's age. The number of hours worked by the mother ranges from 24 when the child is very young, to 30 when the child reaches 11 years of age; conversely, the average number

[32]Out of the 3,563 children interviewed in 1997, 314 do not have information on their parents, 2,069 have siblings and 602 live in households where one (both) parent(s) is (are) not present. Moreover, 52 children have not information on parents' age, education and race and 85 have not test score measures in the period 1997-2007. Table 3.C.4 compares the average values of the most relevant variables in the sample used for the analysis ($N = 434$) with their values in the overall PSID-CDS data ($N = 3243$).

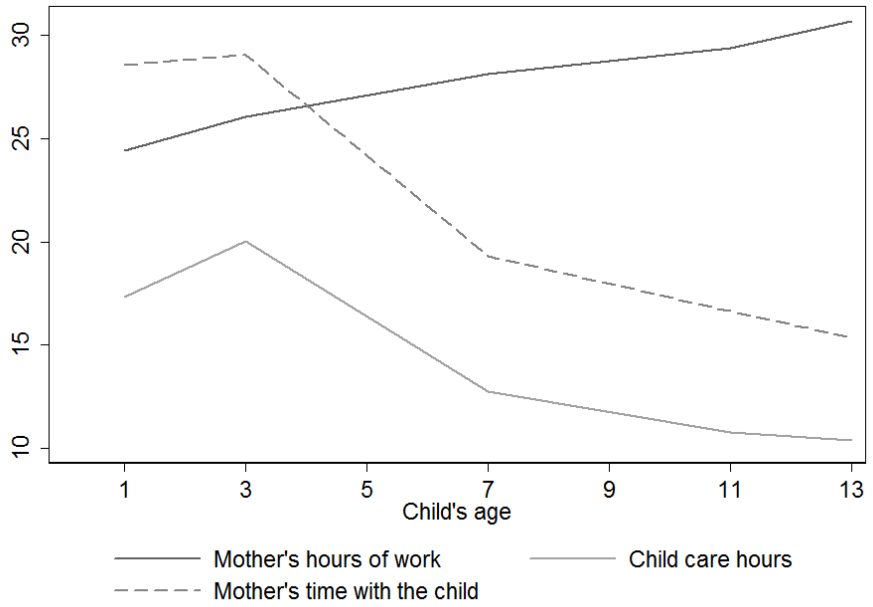
Figure 3.3
LW raw score by child's age.



NOTES. Source: own elaboration from PSID-CDS data.

of hours the child is cared for by someone other than his parents decreases as the child ages, ranging from 17 hours per week in the first years of life to 11 hours per week when he is 11 years old. Notice that the daily amount of time the mother spends at work when the child is younger than 6 almost corresponds to the time the child is cared for by someone else (4.8 hours per day vs 3.5 hours per day). When the child starts going to school, he does spend out of home not only the time in external care but also a fixed amount of school time. If the child spends at school 6 hours per day, he stays out of home almost 8 hours, while the mother works, on average, 5.6 hours per day. This difference shows that the amount of leisure time of the mother significantly increases when the child reaches school age. The average number of hours the child spends with the mother decreases as the child grows up: the mother spends with the child almost 4 to 5 hours per day when the child is younger than 5, while the time drops to 2 to 3 hours per day when the child reaches 6 years of age.

Figure 3.4
Mother's hours of work, time with the child and non-parental child care time per week, by child's age.



NOTES. Source: own elaboration from PSID-CDS data.

Table 3.3
Descriptive statistics on maternal employment, non-parental child care and maternal time by child's age. Means and standard deviation in parentheses.

Child's Age	1-2	3-5	6-10	11-12
Mother's hours of work per week	24.40	26.03	28.10	29.34
	(17.67)	(17.55)	(17.21)	(17.29)
Proportion of working mothers	0.77	0.79	0.82	0.82
	(0.42)	(0.41)	(0.38)	(0.39)
Child care hours per week	17.39	20.02	12.76	10.76
	(19.11)	(19.28)	(17.49)	(16.49)
Mother's time with the child	28.55	29.05	19.31	16.64
	(18.06)	(20.27)	(14.80)	(14.21)

NOTES. Source: own elaboration from PSID-CDS data.

3.6. Results

This section presents the estimated parameters, while subsection 3.6.1 discusses the goodness of fit of the model.

Table 3.4 shows the estimates of the parameters in the mother's utility function. The γs parameters represent the contribution of each observable characteristic of the mother on mother's tastes for leisure, consumption and child's cognitive ability. Figures 3.5, 3.6 and 3.7 report the values taken by each preference parameter by subgroups and by mother's education. While the taste for leisure does not vary across mother's levels of education, more educated mothers care less about consumption. Low skilled mothers have higher preferences for leisure and consumption, while there are not differences in tastes induced by mother's race. Figure 3.7 shows the value of the preference parameter for child's ability. For any group, one more year of education implies an higher taste for child's ability, even though the marginal contribution of each year decreases as education increases. Moreover, more skilled mothers care more about their child's ability than the low skilled ones.

The parameter ρ indicates the value the mother poses on the child's level of ability reached in the last developmental period. The estimated value is roughly 34. To give an intuition to this number, consider the case of an infinitely lived household with a discount factor in the last period that is equal to the factor in all previous periods. Since $\beta = 0.95$, the value of this parameter would be equal to $\rho = \sum_{k=0}^{\infty} \beta^k = \frac{1}{1-\beta} = 20$. Having found that the discount factor in the last period is higher than this value means that, in $T+1$, the mother poses additional weight on child's ability, because she may think it represents

Table 3.4
Estimated parameters for mother's utility function.

Mother's Utility Function Parameters		
$\gamma_{2\ MotherEducation}$	contribution of mother's education to α_2	-0.2094
		(0.0878)
$\gamma_{2\ MotherRace}$	contribution of mother's race to α_2	0.1369
		(0.1064)
$\gamma_{3\ MotherEducation}$	contribution of mother's education to α_3	0.0169
		(0.0425)
$\gamma_{3\ MotherRace}$	contribution of mother's race to α_3	0.1104
		(0.0514)
ρ	weight on future child's ability in the last period	34.1643
		(1.8554)
p	hourly price of child care	5.1502
		(0.6517)
Mother's Skills Distribution		
$\mu_{0\ high}$	skill level for high type	3.2011
		(0.8090)
$\mu_{0\ low}$	skill level for low type	1.2603
		(0.1833)
$\pi_{m\ high}$	proportion high skilled	0.3203
		(0.1006)
$\pi_{m\ low}$	proportion low skilled	0.6797
		(...)

NOTES. Standard errors are estimated with non-parametric bootstrap; standard errors for type proportions are computed using the delta method. See appendix 3.B.3 for further details. Since type proportions should add to one, so that one of the type probabilities is obtained as a residual, I do not report standard errors in this case.

Table 3.5
Estimated parameters for the wage and income processes.

Wage Equation Parameters		
μ_1	coefficient of mother's education	0.0788
		(0.0445)
μ_2	coefficient of mother's age	0.0018
		(0.0116)
μ_3	coefficient of mother's age squared	−0.0006
		(0.0008)
μ_4	coefficient of mother's race	−0.0156
		(0.0038)
σ_ϵ	standard deviation transitory shock	0.3031
		(0.0111)
Household Income Process		
μ_{inc}	mean	15.9606
		(0.3432)
σ_{inc}	standard deviation	12.8553
		(1.2765)

NOTES. Standard errors are estimated with non-parametric bootstrap. See appendix 3.B.3 for further details.

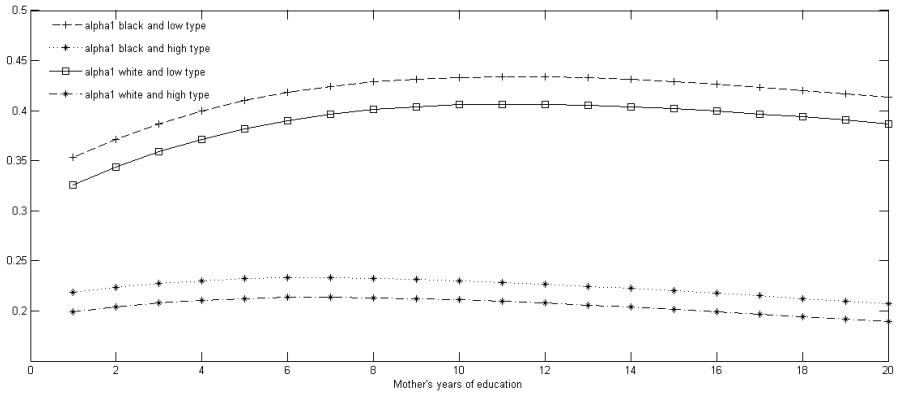
"an important initial condition for developmental processes that begin in the later teen years" (Del Boca et al., 2010).

The panel at the bottom of table 3.4 reports the parameters identifying the mother's skills distribution. The skills level of high type mothers is more than two times higher than the corresponding level for the low type. This implies a significant difference in the offer that mothers with different skills receive from the market and, as a consequence, in their employment decisions. The proportion of low skilled mothers in the sample is equal to 68 percent.

Table 3.5 shows the results from the wage equation and the income process. All parameters in the wage equation have expected signs and reasonable magnitudes. The education effect on wages indicates that wage increases by 7.8 percent with each additional year of education. This effect is in line with the one found by Keane and Moffitt (1998) but slightly higher than the estimated effects in Del Boca et al. (2010) (4.8 percent), Bernal and Keane (2010) (4 percent) and Bernal (2008) (2 percent).

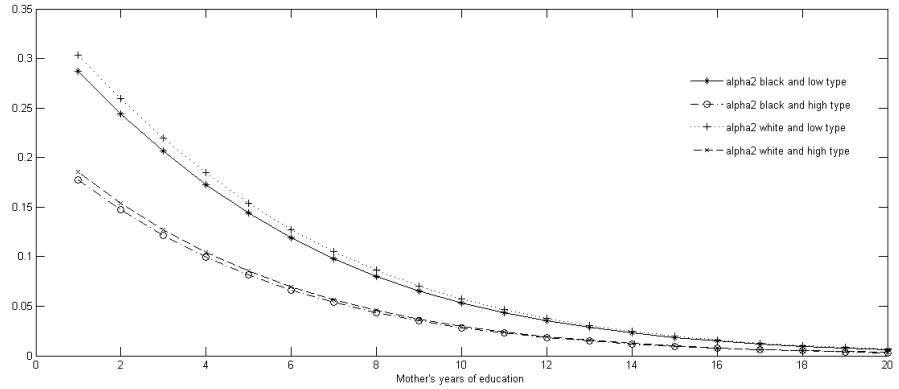
Table 3.6 presents the results of the parameters in the child's cognitive ability production function and the initial level of ability. The parameters shown in the first panel of this table represent the slope of each input productivity with respect to child's age. To simplify the presentation of the results, figures 3.8 and 3.9 show the time-varying elasticities as a function of child's age. Figure 3.8 reports the elasticities of child ability with respect to maternal time and non-parental child care time, while figure 3.9 reports the elasticities with respect to household income and the child's ability in the previous period. First of all, notice that the elasticity with respect to all inputs is higher during early years and decreases over time, as suggested by previous studies on human capital accumulation (Carneiro and Heckman, 2003, Heckman, 2008). According to figure 3.8, the elasticity of child's cognitive ability with respect to external child care is slightly higher than the one with respect to maternal time. The elasticity of child's ability with respect to maternal time ranges from 0.65 when the child is 1 year old to less than 0.05 when the child has

Figure 3.5
Preference parameters for leisure by subgroups and by level of education.



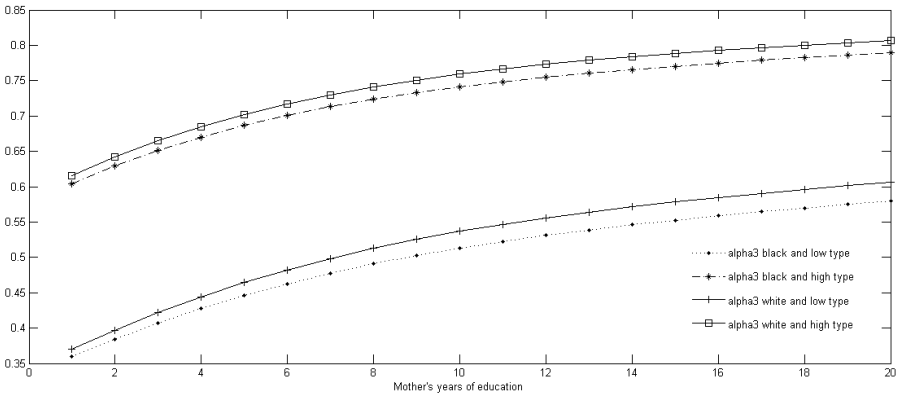
NOTES. This graph represents the estimated preference parameter for leisure by mother's years of education and for different subgroups, identified through mother's race and mother's skills level. The parameter is defined as $\alpha_1 = f_1(MotherEdu, MotherRace, \gamma_1, \Gamma_2, \Gamma_3, \mu_0)$ where $\gamma_1 = 0$ and the estimated values for Γ_3, Γ_2 and μ_0 are shown in table 3.4. See appendix 3.B.1 for further details.

Figure 3.6
Preference parameters for consumption by subgroups and by level of education.



NOTES. This graph represents the estimated preference parameter for consumption by mother's years of education and for different subgroups, identified through mother's race and mother's skills level. The parameter is defined as $\alpha_2 = f_2(MotherEdu, MotherRace, \gamma_1, \Gamma_2, \Gamma_3, \mu_0)$ where $\gamma_1 = 0$ and the estimated values for Γ_3, Γ_2 and μ_0 are shown in table 3.4. See appendix 3.B.1 for further details.

Figure 3.7
Preference parameters for child's ability by subgroups and by level of education.



NOTES. This graph represents the estimated preference parameter for child's ability by mother's years of education and for different subgroups, identified through mother's race and mother's skills level. The parameter is defined as $\alpha_3 = f_3(MotherEdu, MotherRace, \gamma_1, \Gamma_2, \Gamma_3, \mu_0)$ where $\gamma_1 = 0$ and the estimated values for Γ_3, Γ_2 and μ_0 are shown in table 3.4. See appendix 3.B.1 for further details.

13 years of age. These estimates are higher than the values estimated by Del Boca et al. (2010) for the early years, but lower from age 5 on. For instance, Del Boca et al. (2010) find that the coefficient for maternal time when the child is 1 year old is equal to 0.25, while it is equal to 0.1 when the child is aged 8 years. At the same age, figure 3.8 reports a coefficient roughly equal to 0.05.[33]

These estimates should also be compared with existing studies evaluating the impacts of maternal employment and child care, using the information on mother's time out of work as a proxy for maternal time with the child. For instance, Bernal (2008) finds that one year of full-time work and external child care use reduces child's score by 1.8 percent; Bernal and Keane (2011, 2010) estimate a reduction in child's cognitive assessment due to one year of full-time work and external child care use of around 2 percent.

According to figure 3.8, if maternal time reduces by 10 percent when the child is 1 year old, because of mother's employment, the child's cognitive ability decreases by 6.5 percent. Assuming that the mother uses external child care for an equal amount of time, child's cognitive ability increases by 7.1 percent. This means that the reduction in child's ability due to the reduction in maternal time can be compensated by the use of external child care services, so that the overall effect of maternal employment turns out to be null or very small, but positive. This result is completely new in the literature and strongly confirms that using the time out of work as a proxy for maternal time with the child overestimates the real amount of time spent by the child with the mother, as well as its productivity. Section 3.7.1 further confirms this issue, presenting the results of a counterfactual exercise where the model has been estimated setting $\tau = TT - h$ and $\alpha_1 = 0$. In this scenario, the mother chooses zero leisure and maternal time with the child is proxied with the total time endowment net of working time.

Moreover, the specification of the model allows to identify the mechanisms with which maternal employment affects child development. In fact, despite having a negative effect due to the reduction in maternal time with the child, this impact can be compensated by child care facilities providing other inputs for child's cognitive development. Notice that maternal employment is not detrimental for child's development as long as external child care has at least the same productivity than maternal time.

Figure 3.8 shows that the coefficients of both external child care and maternal time strongly decrease over time. This pattern can be due to two main reasons. On one hand, it may depend on the fact that starting from compulsory school age, children start receiving other inputs that are unobserved in the data and not taken into account in the model. Hence, both maternal time and non-parental child care may play a weaker role. On the other hand, the steep fall in external child care productivity when the child starts going

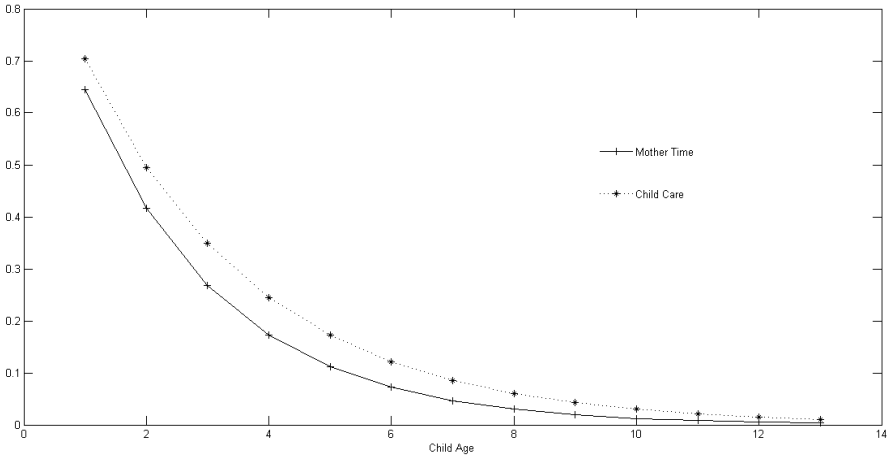
[33]The results reported in figure 3.8 are also close to the ones found recently by Del Boca et al. (2012), even though the two studies are not directly comparable. In fact, Del Boca et al. (2012) find that 1 additional hour of maternal time during childhood (when the child is aged 5 years) leads to a 1 percent of a standard deviation increase in child's cognitive assessment during adolescence (when the child is aged 10 years). In the present study, the coefficient for maternal time at each child's age represents the elasticity of the child's ability in the subsequent period with respect to an additional hour with the mother in the immediately preceding period. The coefficient of maternal time when the child is 5 years old implies than a 1 percent increase in maternal time at age 5 increases child's cognitive ability at age 6 by 0.12 percent, corresponding to 0.83 percent of a standard deviation ($(0.12/14.47) = 0.0083$). The higher effect found in Del Boca et al. (2012) may be due to this timing issue, since their estimate may incorporate the potential multiplicative effect of maternal time from age 5 up to age 10.

Table 3.6
Estimated parameters for the child's cognitive ability production function.

CAPF Parameters		
ξ_1	slope productivity of maternal time	-0.4388
		(0.1299)
ξ_2	slope productivity external child care	-0.3514
		(0.1169)
ξ_3	slope productivity income	-0.0566
		(0.0510)
ξ_4	slope productivity child's ability in previous period	-0.1026
		(0.1215)
σ_v	standard deviation measurement error in test score	15.2839
		(1.2061)
Child's Initial Ability Parameters		
$\psi_{0\ high}$	skill level for high type children	-52.3704
		(4.8011)
$\psi_{0\ low}$	skill level for low type children	-108.0380
		(13.7080)
$\pi_{c\ high}$	proportion high skilled children	0.0001
		(3.3533)
$\pi_{c\ low}$	proportion low skilled children	0.9999
		(...)
η_1	correlation child's endowment and mother's education	2.0618
		(1.2880)
η_2	correlation child's endowment and father's education	0.2255
		(1.1359)

NOTES. Standard errors are estimated with non-parametric bootstrap; standard errors for type proportions are computed using the delta method. See appendix 3.B.3 for further details. Since type proportions should add to one, so that one of the type probabilities is obtained as a residual, I do not report standard errors in this case.

Figure 3.8
Maternal time and non-parental child care productivity.



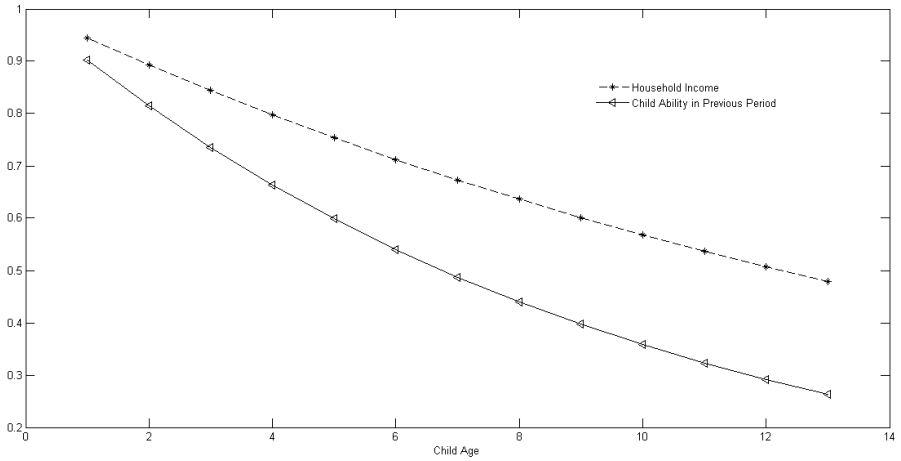
NOTES. This graph represents the productivity parameters for maternal time (τ_t) and non-parental child care (i_t) as a function of child's age $t = 1, 2, \ldots 13$. These parameters are defined as

$$\delta_i = exp(\xi_i t)$$

where $i = 1, 2$ and the estimated values for ξ_1 and ξ_2 are shown in table 3.6.

to kindergarten or primary school can be explained by the different purposes of external child care from the mother's point of view. In fact, the mother may choose a positive amount of child care if she works and needs someone looking after the child, but also if she thinks it can represent an input for subsequent child's development. The educational role of child care can be less important when the child starts going to school, because he is receiving other educational inputs from other institutions, so that from this age on the custodial role can be prevailing. As a consequence, child care productivity decreases even if the amount of time spent in external care remains constant.

Figure 3.9
Income and previous period child's ability productivity.



NOTES. This graph represents the productivity parameters for income (I_t) and child's ability (A_t) as a function of child's age $t = 1, 2, \ldots 13$. These parameters are defined as

$$\delta_i = exp(\xi_i t)$$

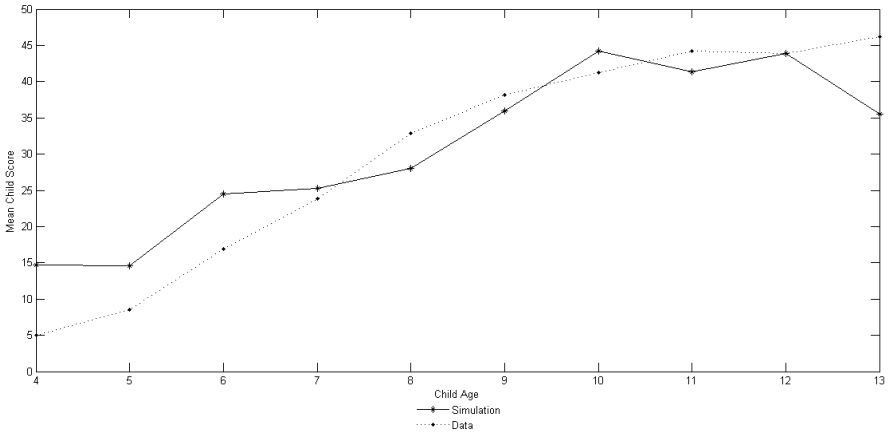
where $i = 3, 4$ and the estimated values for ξ_3 and ξ_4 are shown in table 3.6.

Figure 3.9 shows the productivity of both household income and child's ability in the previous period. The result for household income seems in line with existing literature saying that economic conditions in early and middle childhood are more important for children's cognitive outcomes than those during adolescence (Duncan and Brooks-Gunn, 1997, Duncan, Yeung, Brooks-Gunn, and Smith, 1998, Levy and Duncan, 2012). It is also interesting to note that the productivity of the child's ability in the previous period is higher than the ones for maternal time and external child care. This can be explained by the fact that when the child ages he receives other inputs that are not included in the model (e.g., school) and that become more effective as he grows up.[34]

These results are robust to alternative specifications that are presented in appendix 3.E. More precisely, I check the robustness of the results on the following dimensions: (i) the definition of the terminal period; (ii) the definition of the variable for maternal time; (iii) the specification of the wage and income processes that does not allow any correlation between the two; (iv) the specification of the child's initial endowment.

[34]Due to the assumption implied by the value-added functional form, if the level of child's ability in every period is a sufficient statistic for all the inputs received by the child in the previous period, the productivity of A_t should incorporate also the effects of inputs that I am not observing in the data.

Figure 3.10
Goodness of fit for child's test score measure by child's age.



NOTES. Actual data represent PSID-CDS data on children aged 0-12 in 1997, with at least one test score measure and without siblings. See section 3.5 and appendix 3.C for further details on the data. Simulated data represent the data obtained simulating the model described in section 3.3 and 3.4.1 and setting the parameters at the estimated values shown in tables 3.4, 3.5 and 3.6.

Table 3.7
Goodness of fit for mother's wage and household income.

	Actual Data	**Simulated Data**
All sample		
Mean mother's wage	14.2510	14.7531
Sd mother's wage	10.1874	16.6083
Mean household income	17.6326	16.0272
Sd household income	12.8244	12.8255
Wage by mother's education		
Some college education	16.3756	16.6014
High School	12.0478	12.6266
Wage by mother's race		
White	15.0246	14.8084
Black	12.8967	14.6671

NOTES. Actual data represent PSID-CDS data on children aged 0-12 in 1997, with at least one test score measure and without siblings. See section 3.5 and appendix 3.C for further details on the data. Simulated data represent the data obtained simulating the model described in section 3.3 and 3.4.1 and setting the parameters at the estimated values shown in tables 3.4, 3.5 and 3.6. Some college education stems for more than 12 years of education; high school education stems for 12 years of education.

3.6.1. Goodness of fit of the model. The reliability of the results and the credibility of the counterfactual exercise and policy simulations described below depend on how the model fits the data.

Figure 3.10 shows the model fit for the child's score measure. Despite there being some differences between the actual and simulated data for the child's first years of life, the model predicts quite well the pattern of the score measure for subsequent child's ages.

Table 3.7 shows how the model performs in fitting the data concerning the wage and the income processes. Specifically, it shows the average and standard deviation of wage

Table 3.8
Goodness of fit for mother's choices.

	Actual Data	**Simulated Data**
Hours of work	27.1166	30.8259
External child care hours	14.6839	10.2375
Maternal time with the child	21.0582	18.3568

NOTES. Actual data represent PSID-CDS data on children aged 0-12 in 1997, with at least one test score measure and without siblings. See section 3.5 and appendix 3.C for further details on the data. Simulated data represent the data obtained simulating the model described in section 3.3 and 3.4.1 and setting the parameters at the estimated values shown in tables 3.4, 3.5 and 3.6.

and income, observed in the actual and in the simulated data. The model behaves well for the prediction of average wage and income and there are not differences between the actual and simulated data concerning the standard deviation of income. Moreover, it reproduces the patterns in the data concerning the average wage by mother's education, while the average wage of black mothers is slightly overestimated. Table 3.8 presents the average values for the choice variables. The model predicts an higher amount of working time and a slightly lower maternal time with the child with respect to the data. Finally, external child care time is narrowly underestimated.

3.7. Counterfactual exercises

In this section, I use the estimated model to perform several counterfactual exercises. Subsection 3.7.1 presents the results from the estimation of the model where maternal time with the child is approximated from maternal working time, as it is usually done in the literature. Then, in subsection 3.7.2, I use the estimated model to simulate the effects of policies (i) increasing household income, by offering a lump-sum grant to households with children, (ii) increasing the wage offers by 50 percent, or (ii) subsidizing external child care, setting the price of the service at 1 US$ per hour.

3.7.1. Leisure-minimizing preferences. The main contribution of this work is to estimate the effect of maternal employment and external child care taking into account the actual time spent by the mother with the child.

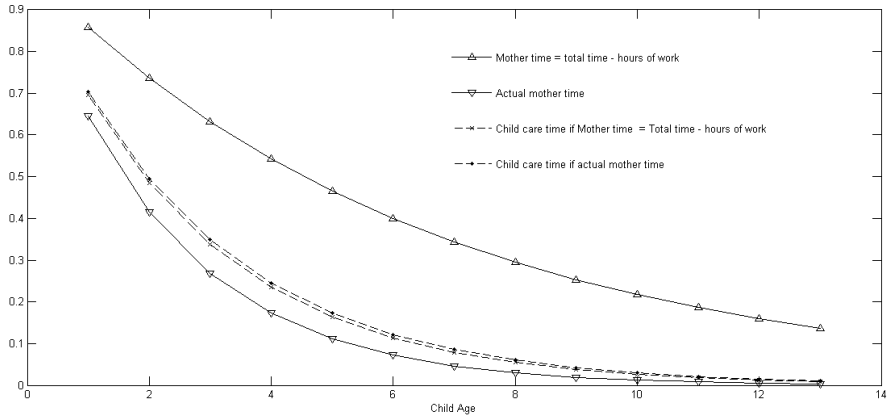
In the literature it has been usually assumed that maternal time can be proxy by the mother's total time endowment net of working time. If this is the case, the mother does not care about leisure and spends all the time out of work with the child. In order to see what are the implications of this assumption, I re-estimate the model setting the preference parameter for leisure $\alpha_1 = 0$ and defining maternal time with the child as the difference between the total time endowment and the time spent at work, i.e. $\tau = TT - h$.

Figure 3.11 reports the elasticity of child's ability with respect to maternal time and external child care in this counterfactual exercise. For comparison purposes, the figure reports also the elasticities found in the main analysis and already presented in figure 3.8; they are labeled as "actual time". Notice that the parameters for external child care do not change across specifications, while the estimates for the elasticity of child's ability with respect to maternal time differ substantially. In this counterfactual scenario, the elasticity of child's ability with respect to maternal time ranges from 0.86 when the child is 1 year

old to 0.1 when the child is aged 13. These values imply that if maternal time reduces by 10 percent, the child's cognitive ability decreases by 8.6 percent. If the same amount of time is spent in external child care, child's cognitive ability increases by almost 7 percent. Thus, in this case, the reduction in child's ability due to the absence of the mother is only partially compensated by the use of external child care. The final effect of mother's work is then a 2 percent decline in child's ability. This result replicates what has been found before in the literature, in particular in studies using structural estimation (Bernal, 2008, Bernal and Keane, 2010).

The difference between the estimates found in this chapter and the results found before in the literature is very likely to depend on the way of defining maternal time. If maternal time with the child is interpreted as all the time available to the mother net of working time, assuming that the mother does not have any leisure, this is very likely to overestimate maternal time productivity and the negative effect of maternal employment. Instead, if an actual measure of maternal time is used, allowing the mother to allocate the time out of work between leisure and care of the child, maternal employment is found not to be detrimental for child's development.

Figure 3.11
Productivity parameters for maternal time and child care obtained assuming leisure-minimizing preferences of the mother. Comparison with the corresponding parameters found in the main analysis.



NOTES. 'Mother time = total time - hours of work' and 'child care time if mother time = total time - hours of work' represent the productivity parameters of maternal time and external child care, respectively, obtained from the estimation of the model setting $\alpha_1 = 0$ and $\tau = TT - h$, where α_1 is the preference parameter for leisure and $TT = 112$. 'Actual mother time' and 'Child care if actual mother time' represent the productivity parameters of maternal time and external child care, as already shown in figure 3.8.

3.7.2. Policy simulations. In this section, I use the estimated model to simulate the effects of policies on mother's choices and behavior as well as on the level of child's ability reached in the last period. More precisely, I simulate the effects of the following policies: (i) a lump-sum subsidy that increases household income by 100 US$ in each period; (ii) an increase in mother's wage by 50 percent, and (iii) a child care subsidy that set the price of child care at 1 US$ per hour. Results are shown in table 3.9.

The first panel of the table refers to a policy providing subsidies to households with children. More precisely, the policy implies that all households in any period receive an additional amount of 100 US$ that increases their (exogenous) income. One may think to this exercise as a simplification of subsidy policies targeted toward poor families and

providing cash transfers not conditioned on specific behavior of the household members. The estimated percentage change shows that the implementation of this policy determines an income effect, for which mothers' employment time decreases. Moreover, mothers adjust their time using more external child care and also dedicating more time to the child. The demand for external child care increases also for a direct income effect induced by the policy. The overall effect on child's ability is large, since the change in income determines a shift not only in the input related to the expenditure for the child (i.e., I_t), but also in external child care and maternal time. Notice that while this policy has a substantially positive effect on child's ability, it also influences the behavior of mothers inducing a strong reduction in their labor market participation.

The second panel of table 3.9 reports the percentage change of the variables induced by an increase in mother's wage by 50 percent in any period. This may be due, for instance, to policies decreasing taxation on mothers' labor income or providing incentives for mothers' employment. The increase in wage, in fact, determines an increase in maternal time at work. The demand for child care is positively affected by this policy through two different channels. First, since mothers are working more they use more child care because they need someone looking after their child. Second, they are also earning more, so that they can buy an higher amount of the service for their child. The same two channels have also an effect on consumption, that is characterized by a percentage change similar to the one in child care. However, the policy has a very little effect on child's ability. This result stresses the importance of taking into account all the plausible channels with which the policy affects the outcomes of interests. In other words, a policy increasing mothers' labor income may be effective in increasing mothers' participation to the labor market, but can fail in having an effect on child's development although improving the economic conditions of the households.

The panel at the bottom of table 3.9 shows the percentage change of the variables after the implementation of a policy setting the price of child care at 1 US$ per hour. Similar policies have been implemented and evaluated during last years, especially in the U.S. and Canada. For instance, Baker et al. (2008) evaluate the effects of a policy setting the out-of-pocket price at 5$ per day in Quebec on maternal employment, child care use and child's outcomes. They find that the policy increases the use of the subsidized service and it also has a positive effect on maternal employment; they do not find any effect on the cognitive outcomes of children. The simulation of this policy has been done setting the hourly price of child care at 1 US$ instead of 5.15 US$, that is the estimated value, as shown in table 3.4. The results of this simulation are in line with the ones found by Baker et al. (2008): the reduction in child care price, in fact, determines a large increase in the use of external child care but also an increase in mother's net wage. The substitution effect seems to prevail, since mothers' labor supply increases after the policy, while maternal time with the child and leisure seem to be unaffected. However, differently from Baker et al. (2008), the simulation of the policy yields an increase in the child's ability, induced by the increase in external child care use.

Table 3.9
Policy simulations.

Increase in household income		
	Baseline	Percentage change
Test score measure in the last period	37.4241	50.8744
Child's ability in the last period	7.0119	431.3410
Hours of work	30.8259	−24.6236
Maternal time with the child	18.3568	4.4408
External child care time	10.2375	16.3742
Leisure	64.6404	9.2906
Consumption	482.5416	17.1592
Increase in mother's wage		
	Baseline	Percentage change
Test score measure in the last period	37.4241	0.1884
Child's ability in the last period	7.0119	1.0525
Hours of work	30.8259	2.3768
Maternal time with the child	18.3568	−0.5555
External child care time	10.2375	49.5170
Leisure	64.6404	−0.8584
Consumption	482.5416	49.5000
Reduction in child care price		
	Baseline	Percentage change
Test score measure in the last period	37.4241	0.8772
Child's ability in the last period	7.0119	4.5409
Hours of work	30.8259	7.1795
Maternal time with the child	18.3568	−0.0005
External child care time	10.2375	415.0235
Leisure	64.6404	−0.0045
Consumption	482.5416	0.0027

NOTES. This table reports percentage changes with respect to the baseline levels from (i) an increase in household income by 100 US$ per week, (ii) an increase in mother's wage by 50 percent, and (iii) a policy setting external child care price at 1 US$ per hour. Test score measure in the last period is the value of the simulated test score at the end of period $t = 12$. Child's ability in the last period is the value of the simulated child's ability at the end of period $t = 12$.

3.8. Concluding remarks

This chapter proposes and estimates a behavioral model where the labor supply, non-parental child care and time allocation choices of the mother are considered endogenous. In contrast to all existing studies in the literature, this chapter takes into account the additional choice the mother makes concerning the time allocation between leisure and time with the child.

Maternal time and external child care serve as inputs in a child's development process that represents a constraint to the mother's utility maximization problem. The model is estimated using U.S. data from the Panel Study of Income Dynamics (PSID) and its Child Development Supplement (CDS) conducted in 1997, 2002 and 2007. The parameters of the model are estimated using a simulated minimum distance estimator that minimizes the distance between several data statistics and their simulated counterparts.

The results suggest that maternal employment does not have a negative effect on child development, as long as the reduction in maternal time is compensated for by the alternative forms of care available to the mother. In fact, even though maternal employment reduces the amount of time the child spends with the mother, this negative effect on child's ability can be compensated for by a positive effect induced by non-parental child care attendance for the same amount of time.

Previous literature has neglected the additional choice of the mother between leisure time and maternal time with the child, defining the variable maternal time as the total time endowment available to the mother net of working time. It implies assuming that the mother does not care about leisure and that she spends all available time with the child. A counterfactual exercise that I perform using the estimated model shows that this assumption overestimates the amount of time spent by the mother with the child, as well as its productivity for child's development. In fact, if the model is estimated under this framework, maternal employment has a detrimental effect, since the reduction in maternal time cannot be compensated for by the use of external child care. This confirms that in order to estimate the effect of maternal employment and external child care on child's development it is important to take into account also the additional choice the mother makes concerning the time allocation out of work.

The policy simulations performed using the estimated model suggest that the policy maker should take into account all the potential effects and mechanisms with which the policies can affect the outcomes of interests. In fact, even though these simulations allow to only evaluate "local" effects, they show that policies aimed at increasing participation of mothers in the labor market, or at improving the economic conditions of poor households, may not necessarily have the same effect on child's development. Similarly, policies decreasing the cost of using external child care can induce an higher use of the service, but may have very small effects on either mothers' participation or child's ability.

The model presented in this chapter has some limitations that leave space for additional improvements. First, the model is assuming a constant and unitary elasticity of substitution across inputs and goods. However, the mother's decision making process may change if one takes into account the substitutability or complementarity of the inputs. For instance, it would be interesting to analyze in more detail whether maternal time or external child care time are complements to rather than substitutes in the child's ability production function. Second, the model only considers a cognitive ability production function, ignoring the production function for non-cognitive skills. However, there is a growing literature saying that the main contribution of external child care, especially if received during early childhood, is through the development of noncognitive skills, that are also likely to be used in adult life and matter for education and labor market outcomes (Cunha et al., 2006, Heckman et al., 2006). It would be interesting to consider an application of the model presented in this chapter to the development of noncognitive skills.

3.A. Analytic solution of the model

In this appendix I derive analytically the closed-form solutions of the model, for all the choice variables.

The process of backward induction involves the solution of the optimization problem in each period, starting from the last one, T. Consider first the choice variables i_t and τ_t. The first step is to find the optimal child care and time input decisions at time T. The value function of the mother at period T can be written as:

$$V_T = max_{i_T,\tau_T}\ \alpha_1 ln(TT-h_T-\tau_T)+\alpha_2 ln(w_T h_T+I_T-pi_T)+\alpha_3 ln(A_T)+E_T\beta\{\tilde{V}_{T+1}+\rho\alpha_3 lnA_{T+1}\} \tag{3.A.1}$$

where the variables l_T and c_T have been already substituted using the time and budget constraints. Notice that the expectation operator in (3.A.1) is with respect to the terminal period value function, as defined in (3.7).

The optimal solutions for both i_T^c and τ_T^c at period T, conditional on h_T, are given by the solutions of the following first order conditions (FOCs):

$$\begin{aligned} i_T^c &\Rightarrow \frac{\partial V_T}{\partial i_T} = 0 \\ \tau_T^c &\Rightarrow \frac{\partial V_T}{\partial \tau_T} = 0 \end{aligned} \tag{3.A.2}$$

Due to the value-added specification of the child cognitive ability production function, as defined by (3.4), child ability in period $T+1$ is a function of the inputs received by the child at period T. Hence, the conditions in (3.A.2) can be rearranged, using total differential, in the following way:

$$\begin{aligned} i_T^c &\Rightarrow \frac{\partial \bar{V}_T}{\partial i_T} + \frac{\partial V_{T+1}}{\partial lnA_{T+1}} \times \frac{\partial lnA_{T+1}}{\partial i_T} = 0 \\ \tau_T^c &\Rightarrow \frac{\partial \bar{V}_T}{\partial \tau_T} + \frac{\partial V_{T+1}}{\partial lnA_{T+1}} \times \frac{\partial lnA_{T+1}}{\partial \tau_T} = 0 \end{aligned} \tag{3.A.3}$$

where $\bar{V}_T$ is the current utility in period T:

$$\bar{V}_T = \alpha_1 ln(TT - h_T - \tau_T) + \alpha_2 ln(w_T h_T + I_T - pi_T) + \alpha_3 ln(A_T)$$

The corresponding derivatives[35] are given by the following expressions:

[35]The second term of the expressions defined in (3.A.3) is derived using the logarithm of A_{T+1} just for computational convenience. The results are the same computing $\frac{\partial V_{t+1}}{\partial A_{t+1}} \times \frac{\partial V_{t+1}}{\partial i_t}$ and $\frac{\partial V_{t+1}}{\partial A_{t+1}} \times \frac{\partial V_{t+1}}{\partial \tau_t}$, i.e. substituting the CAPF in exponential form:

$$A_{T+1} = \tau_T^{\delta_{1T}} i_T^{\delta_{2T}} I_T^{\delta_{3T}} A_T^{\delta_{4T}}$$

In this case, the second terms of the expressions in (3.A.3) become:

$$\begin{aligned} \frac{\partial V_{T+1}}{\partial A_{T+1}} \times \frac{\partial A_{T+1}}{\partial i_T} &= \frac{\beta\rho\alpha_3}{\tau_T^{\delta_{1T}} i_T^{\delta_{2T}} I_T^{\delta_{3T}} A_T^{\delta_{4T}}} (\tau_T^{\delta_{1T}} i_T^{\delta_{2T}-1} I_T^{\delta_{3T}} A_T^{\delta_{4T}}) = \beta\rho\alpha_3 \frac{\delta_{2T}}{i_T} \\ \frac{\partial V_{T+1}}{\partial A_{T+1}} \times \frac{\partial A_{T+1}}{\partial \tau_T} &= \frac{\beta\rho\alpha_3}{\tau_T^{\delta_{1T}} i_T^{\delta_{2T}} I_T^{\delta_{3T}} A_T^{\delta_{4T}}} (\tau_T^{\delta_{1T}-1} i_T^{\delta_{2T}} I_T^{\delta_{3T}} A_T^{\delta_{4T}}) = \beta\rho\alpha_3 \frac{\delta_{1T}}{\tau_T} \end{aligned}$$

that are equivalent to (3.A.6) and (3.A.7).

$$\frac{\partial \bar{V}_T}{\partial i_T} = \frac{-p\alpha_2}{w_T h_T + I_T - p i_T} \tag{3.A.4}$$

$$\frac{\partial \bar{V}_T}{\partial \tau_T} = \frac{-\alpha_1}{TT - h_T - \tau_T} \tag{3.A.5}$$

$$\frac{\partial V_{T+1}}{\partial lnA_{T+1}} \times \frac{\partial lnA_{T+1}}{\partial i_T} = (\beta\rho\alpha_3)\left(\frac{\delta_{2T}}{i_T}\right) \tag{3.A.6}$$

$$\frac{\partial V_{T+1}}{\partial lnA_{T+1}} \times \frac{\partial lnA_{T+1}}{\partial \tau_T} = (\beta\rho\alpha_3)\left(\frac{\delta_{1T}}{\tau_T}\right) \tag{3.A.7}$$

and the FOCs become:

$$i_T^c \Rightarrow \frac{-p\alpha_2}{w_T h_T + I_T - p i_T} + (\beta\rho\alpha_3)\left(\frac{\delta_{2T}}{i_T}\right) = 0 \tag{3.A.8}$$

$$\tau_T^c \Rightarrow \frac{-\alpha_1}{TT - h_T - \tau_T} + (\beta\rho\alpha_3)\left(\frac{\delta_{1T}}{\tau_T}\right) = 0$$

The solutions for both inputs at period T are given by:

$$i_T^c = \frac{\beta\delta_{2T} D_{T+1}}{p(\alpha_2 + \beta\delta_{2T} D_{T+1})}(w_T h_T + I_T) \tag{3.A.9}$$

$$\tau_T^c = \frac{\beta\delta_{1T} D_{T+1}}{\alpha_1 + \beta\delta_{1T} D_{T+1}}(TT - h_T) \tag{3.A.10}$$

where $D_{T+1} = \frac{\partial V_{T+1}}{\partial lnA_{T+1}} = \rho\alpha_3$.

These solutions can be substituted into the value function of the mother at period T, in order to get $V_T(i_T^c, \tau_T^c)$.

Consider now period $T-1$. The value function for this period is:

$$\begin{aligned} V_{T-1} = max_{i_{T-1},\tau_{T-1}}\ & \alpha_1 ln(TT - h_{T-1} - \tau_{T-1}) + \alpha_2 ln(w_{T-1}h_{T-1} + I_{T-1} - p i_{T-1}) + \alpha_3 ln(A_{T-1}) + \\ & + E_{T-1}\beta\{\alpha_1 ln(TT - h_T - \tau_T^C) + \alpha_2 ln(w_T h_T + I_T - p i_T^C) + \alpha_3 lnA_T + \\ & + \beta\{\tilde{V_{T+1}} + \rho\alpha_3[\delta_{1T} ln\tau_T^C + \delta_{2T} lni_T^C + \delta_{3T} lnI_T + \delta_{4T} lnA_T]\}\} \end{aligned} \tag{3.A.11}$$

The expectation in (3.A.11) is with respect to the value function at period T ($V_T(i_T^c, \tau_T^c)$) *and* the terminal period value function at period $T+1$.

Applying total differential, the solutions for both inputs in period $T-1$ are given by:

$$i_{T-1}^c \Rightarrow \frac{\partial \bar{V}_{T-1}}{\partial i_{T-1}} + \frac{\partial V_T}{\partial lnA_T} \times \frac{\partial lnA_T}{\partial i_{T-1}} = 0 \tag{3.A.12}$$

$$\tau_{T-1}^c \Rightarrow \frac{\partial \bar{V}_{T-1}}{\partial \tau_{T-1}} + \frac{\partial V_T}{\partial lnA_T} \times \frac{\partial lnA_T}{\partial \tau_{T-1}} = 0 \tag{3.A.13}$$

where

$$\bar{V}_{T-1} = \alpha_1 ln(TT - h_{T-1} - \tau_{T-1}) + \alpha_2 ln(w_{T-1}h_{T-1} + I_{T-1} - p i_{T-1}) + \alpha_3 ln(A_{T-1})$$

and

$$\frac{\partial \bar{V}_{T-1}}{\partial i_{T-1}} = \frac{-p\alpha_2}{w_{T-1}h_{T-1} + I_{T-1} - pi_{T-1}} \tag{3.A.14}$$

$$\frac{\partial \bar{V}_{T-1}}{\partial \tau_{T-1}} = \frac{-\alpha_1}{TT - h_{T-1} - \tau_{T-1}} \tag{3.A.15}$$

$$\frac{\partial V_T}{\partial lnA_T} \times \frac{\partial lnA_T}{\partial i_{T-1}} = (\alpha_3 + \beta\alpha_3)\left(\frac{\delta_{2T-1}}{i_{T-1}}\right) \tag{3.A.16}$$

$$\frac{\partial V_T}{\partial lnA_T} \times \frac{\partial lnA_T}{\partial \tau_{T-1}} = (\alpha_3 + \beta\alpha_3)\left(\frac{\delta_{1T-1}}{\tau_{T-1}}\right) \tag{3.A.17}$$

Substituting (3.A.14),(3.A.15),(3.A.16) and (3.A.17) into (3.A.12) and (3.A.13) yields:

$$i^c_{T-1} \Rightarrow \frac{-p\alpha_2}{w_{T-1}h_{T-1} + I_{T-1} - pi_{T-1}} + (\alpha_3 + \beta\alpha_3)\left(\frac{\delta_{2T-1}}{i_{T-1}}\right) = 0 \tag{3.A.18}$$

$$\tau^c_{T-1} \Rightarrow \frac{-\alpha_1}{TT - h_{T-1} - \tau_{T-1}} + (\alpha_3 + \beta\alpha_3)\left(\frac{\delta_{1T-1}}{\tau_{T-1}}\right) = 0 \tag{3.A.19}$$

The solutions for both choice variables in period $T-1$, conditional on h_{T-1}, are then:

$$i^c_{T-1} = \frac{\beta\delta_{2T-1}D_T}{p(\alpha_2 + \beta\delta_{2T-1}D_T)}(w_{T-1}h_{T-1} + I_{T-1}) \tag{3.A.20}$$

$$\tau^c_{T-1} = \frac{\beta\delta_{1T-1}D_T}{\alpha_1 + \beta\delta_{1T-1}D_T}(TT - h_{T-1}) \tag{3.A.21}$$

where

$$D_T = \frac{\partial V_T}{\partial lnA_T} = \alpha_3 + \beta\delta_{4T}D_{T+1}$$

The solutions for period $T-1$, given by equations (3.A.20) and (3.A.21), can be substituted in (3.A.11) in order to get $V_{T-1}(i^c_{T-1}, \tau^c_{T-1})$. This expression can be used to write down the value function at period $T-2$. Using the same process described for periods T and $T-1$ and computing the corresponding derivatives yields the solutions for period $T-2$. The solutions for all the periods up to period $t=1$ can be retrieved similarly.

At the end, two sequences of optimal choices can be obtained. The sequence of optimal non-parental child care choices, conditional on mother's labor supply, is given by:

$$i_T^c = \frac{\beta\delta_{2T}D_{T+1}}{p(\alpha_2 + \beta\delta_{2T}D_{T+1})}(w_T h_T + I_T) \tag{3.A.22}$$

$$i_{T-1}^c = \frac{\beta\delta_{2T-1}D_T}{p(\alpha_2 + \beta\delta_{2T-1}D_T)}(w_{T-1} h_{T-1} + I_{T-1}) \tag{3.A.23}$$

$$i_{T-2}^c = \frac{\beta\delta_{2T-2}D_{T-1}}{p(\alpha_2 + \beta\delta_{2T-2}D_{T-1})}(w_{T-2} h_{T-2} + I_{T-2}) \tag{3.A.24}$$

$$\vdots$$

$$i_t^c = \frac{\beta\delta_{2t}D_{t+1}}{p(\alpha_2 + \beta\delta_{2t}D_{t+1})}(w_t h_t + I_t) \tag{3.A.25}$$

$$\vdots$$

$$i_2^c = \frac{\beta\delta_{22}D_3}{p(\alpha_2 + \beta\delta_{22}D_3)}(w_2 h_2 + I_2) \tag{3.A.26}$$

$$i_1^c = \frac{\beta\delta_{21}D_2}{p(\alpha_2 + \beta\delta_{21}D_2)}(w_1 h_1 + I_1) \tag{3.A.27}$$

Equation (3.A.25) is equal to (3.8) in the main text. Instead, the sequence of optimal choices for time with the child, conditional on mother's labor supply, is given by:

$$\tau_T^c = \frac{\beta\delta_{1T}D_{T+1}}{(\alpha_1 + \beta\delta_{1T}D_{T+1})}(TT - h_T) \tag{3.A.28}$$

$$\tau_{T-1}^c = \frac{\beta\delta_{1T-1}D_T}{(\alpha_1 + \beta\delta_{1T-1}D_T)}(TT - h_{T-1}) \tag{3.A.29}$$

$$\tau_{T-2}^c = \frac{\beta\delta_{1T-2}D_{T-1}}{(\alpha_1 + \beta\delta_{1T-2}D_{T-1})}(TT - h_{T-2}) \tag{3.A.30}$$

$$\vdots$$

$$\tau_t^c = \frac{\beta\delta_{1t}D_{t+1}}{(\alpha_1 + \beta\delta_{1t}D_{t+1})}(TT - h_t) \tag{3.A.31}$$

$$\vdots$$

$$\tau_2^c = \frac{\beta\delta_{12}D_3}{(\alpha_1 + \beta\delta_{12}D_3)}(TT - h_2) \tag{3.A.32}$$

$$\tau_1^c = \frac{\beta\delta_{11}D_2}{(\alpha_1 + \beta\delta_{11}D_2)}(TT - h_1) \tag{3.A.33}$$

Equation (3.A.31) is equal to equation (3.9) in the text. The sequence of values for D_{t+1} is defined in the main text.

Once having found the solutions for both the child care and the time allocation decisions, the solutions for the labor supply can be computed using the same backward procedure. Equation (3.11) represents the optimal labor supply in each period as a function of i_t and τ_t; substituting (3.8) and (3.9), it yields the optimal labor supply choice for each period t, as defined by (3.12).

The unconditional demands for child care and time with the child are derived substituting the labor supply solution into equations (3.8) and (3.9) (corresponding to (3.A.25) and (3.A.31) in this appendix). The final expressions for them are reported in equations (3.14) and (3.15).

3.B. Empirical analysis and estimation

This appendix provides additional details on the empirical analysis performed to estimate the model.

3.B.1. Empirical specification. As stated in section 3.4.1, the definition of the model parameters should ensure that they respect the requirements imposed by the functional form restrictions. In order to respect these requirements without posing additional constraints to the estimation algorithm, I use a suitable transformation of the original parameters for any coefficient on which the model imposes restrictions due to functional form or empirical specification assumptions.

Concerning the parameters in the mother's utility function, they should be positive and sum to one. Following Flinn (2000) and Mroz et al. (2010), I define them as multinomial probabilities and equal to the following expressions:

$$\alpha_1 = \frac{exp(\gamma_1)}{exp(\gamma_1) + exp(X'\gamma_2) + exp(X'\gamma_3 + I(\mu_0 = \mu_{0high}))} \tag{3.B.1}$$

$$\alpha_2 = \frac{exp(X'\gamma_2)}{exp(\gamma_1) + exp(X'\gamma_2) + exp(X'\gamma_3 + I(\mu_0 = \mu_{0high}))} \tag{3.B.2}$$

$$\alpha_3 = \frac{exp(X'\gamma_3 + I(\mu_0 = \mu_{0high}))}{exp(\gamma_1) + exp(X'\gamma_2) + exp(X'\gamma_3 + I(\mu_0 = \mu_{0high}))} \tag{3.B.3}$$

where $X = [MotherEducation, MotherRace]$, γ_1 is normalized to being 0 and μ_0 represents mother's skills. The distribution of mother's skills is explained in the text. A similar transformation has been implemented for parameters representing probabilities, i.e. type proportions of high and low skilled mothers and children. More precisely, the proportion of high skilled mothers is defined as

$$\pi_{mh} = exp(z_m)/(1 + exp(z_m)) \tag{3.B.4}$$

while the proportion of high skilled children is

$$\pi_{ch} = exp(z_c)/(1 + exp(z_c)) \tag{3.B.5}$$

The parameters z_m and z_c are actually estimated and are used to recover the type proportions of high skilled mothers and children. Notice that the proportion of low skilled mothers and children is just derived as a residual, since they must sum to one.

Concerning the CAPF, the parameters in this case should be strictly positive. Hence, I implement the transformation defined by (3.19) that exploits the properties of the exponential function.

The vector of parameters to be estimated is the following:

$$\Theta = \{\Gamma_2, \Gamma_3, \rho, \Xi, \sigma_v, \mu_{0k}, z_{mh}, \Upsilon, \sigma_\epsilon, \psi_{ck}, z_{ch}, \Delta, p, \theta_{inc}\} \tag{3.B.6}$$

where $\Gamma_2 = (\gamma_{2\ MotherEdu}, \gamma_{2\ MotherRace})$, $\Gamma_3 = (\gamma_{3\ MotherEdu}, \gamma_{3\ MotherRace})$, $\Xi = (\xi_1, \xi_2, \xi_3, \xi_4)$, $k = (h, l)$, $\Upsilon = (\mu_1, \mu_2, \mu_3, \mu_4)$, $\Delta = (\eta_1, \eta_2)$ and $\theta_{inc} = (\mu_{inc}, \sigma_{inc})$.

The parameter p represents the hourly price of child care. As in Bernal (2008), it has been estimated as if it were a parameter because the actual distribution of that measure in the data has a large mass toward zero, also for children actually using the service. This

may be due to the usage of informal child care, that can have a zero market price. Using the direct measure available in the data yields an infinite demand for external child care for those using an arrangement with a zero price, regardless of mother's labor income and household earnings.

3.B.2. Estimation. The estimation has been done in two-stages, after having set the discount factor $\beta = 0.95$: the parameters of the income process have been estimated in the first stage, while all remaining parameters have been estimated in the second stage.[36]

After having computed the statistics defined in table 3.1 for the actual data, I proceed with the first-stage estimation of the income parameters. This involves the simulation of the income process, after having drawn from a standard normal distribution $N * R$ times, for every period. This distribution is actually a function of the two parameters that should be estimated, i.e., μ_{inc} and σ_{inc}. The statistics used to estimate these parameters are the average, standard deviation and median income for all the periods. I compute these points for both the actual and the simulated income processes. The SMD estimator for this first stage minimizes an objective function where each moment condition is the distance between the income data moments and their simulated counterparts. Each moment condition is weighted using the inverse of the corresponding statistics in the data. The vector of first-stage estimated parameters is then: $\hat{\theta}_{inc} = (\hat{\mu}_{inc}, \hat{\sigma}_{inc})$.

The second-stage involves the estimation of all remaining parameters using the same estimator. First of all, I simulate the data according to the DGP implied by the model, taking $N * R * T$ draws for wage, error in test score measure and income and $N * R$ draws for child's and mother's skills. Following Keane and Moffitt (1998), I re-draw the errors to simulate the income distribution using the parameters estimated in first stage. In each period, the values for mother's labor supply, non-parental child care and maternal time are derived using the optimal solutions implied by the model.[37] Then, after having simulated the data for all the periods, I compute the statistics defined in table 3.1 from the simulated data.

The estimator used in this second-stage minimizes an objective function where each moment condition is the distance between the data statistics and the simulated counterparts, as summarized by table 3.1:

$$\hat{\theta} = arg\ min\ \hat{g}(\theta)' W \hat{g}(\theta)$$

where

$$\hat{g}(\theta) = \hat{m} - \hat{M}(\theta)$$

$\hat{m}$ is the vector of statistics defined from the actual data, while $\hat{M}(\theta)$ is the vector of simulated statistics according to the model that are functions of the structural parameters to be estimated. W is a positive definite diagonal weighting matrix. According to Cameron and Trivedi (2005, pag. 203), the most efficient minimum distance estimator uses a weighting

[36] Results do not change estimating all parameters in only one stage. However, the estimation in two-stages is less time consuming.

[37] To test numerically the accuracy of the solutions given by the theoretical model, I also perform a grid search, assuming that the mother's decision to work were actually discrete. In other words, I compute the value of the demands for child care and time with the child, as well as the mother's inter temporal utility, for different levels of mother's labor supply (with the number of hours of work ranging from 0 up to the total time endowment) and I define as optimal choices those that provide the highest utility. The solutions do not differ from the ones provided by the theoretical model.

matrix whose elements are estimates of the inverse of the covariance matrix of the vector $\hat{m}$. Given S number of moments and neglecting the off-diagonal elements of the covariance matrix, the weighting matrix is defined as:

$$W = \begin{pmatrix} \hat{V}[\hat{m}_1]^{-1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \hat{V}[\hat{m}_S]^{-1} \end{pmatrix}$$

where $\hat{V}[\hat{m}]$ is estimated with non-parametric bootstrap and according to the formula (Davidson and MacKinnon, 2003, p. 208):

$$\hat{V}\left[\hat{m}\right] = \left[\frac{1}{B}\right] \sum_{b=1}^{B} \left(\hat{m}_b^* - \bar{m}^*\right) \left(\hat{m}_b^* - \bar{m}^*\right)' \text{(3.B.7)}$$

Non-parametric bootstrap (with replacement) has been implemented according to Wooldridge (2002, p. 379): I used a random number generator to obtain N integers, where $N = 434$ represents the sample size of the actual data, and these integers index the observations drawn from the actual distribution of data. Repeating this process B times,[38] it yields B bootstrap samples on which the statistics defined in table 3.1 can be computed: $\hat{m}_b^*$ represents a statistic computed for the sample b, while $\bar{m}^*$ is the average of the statistics across the B samples.

3.B.3. Standard errors. Non-parametric bootstrap with replacement has been used also to compute the standard errors. After having drawn B_{se} samples from the actual data,[39] I repeat the estimation of the parameters for each sample. This yields an empirical distribution of the parameters estimates, from which I can recover a bootstrap estimate of the variance, using the formula (Train, 2009, pag. 201):

$$\hat{V}\left[\hat{\theta}\right] = \left[\frac{1}{B}\right] \sum_{b=1}^{B} \left(\hat{\theta}_b^* - \bar{\theta}^*\right) \left(\hat{\theta}_b^* - \bar{\theta}^*\right)' \text{(3.B.8)}$$

Taking the square root of (3.B.8) yields the bootstrap estimate of the standard errors $se_{\hat{\theta}}$.

The standard errors for the type proportion parameters π_{mh}, π_{ch} have been computed applying the delta method on the non-linear functions (3.B.4) and (3.B.5). Defining $g(z_l) = exp(z_l)/(1 + exp(z_l))$ as the function to be approximated for mothers ($l = m$) and children ($l = c$) respectively, the standard errors of the new parameters π_{mh} and π_{ch} are given by (Davidson and MacKinnon, 2003, chapter 5.6):

$$se_{\hat{\pi}_{lh}} = \left|g'\left(\hat{z}_l\right)\right| se_{\hat{z}_l} \text{(3.B.9)}$$

where $l = m, c$ and $g'\left(\hat{z}_l\right) = \frac{\partial g(\hat{z}_l)}{\partial \hat{z}_l}$.

[38] $B = 200$.
[39] $B_{se} = 50$

3.C. PSID-CDS data

This appendix provides further details on the data used to estimate the model.

The overall dataset is composed by different supplements of the Panel Study of Income Dynamics (PSID) gathered in the period 1985-2007. Table 3.C.1 summarizes the main information on availability and sources of data. Notice the difference in the availability of information between data taken from the main PSID surveys or related to the external child care information, and the other variables taken from the CDS supplements of the PSID. PSID surveys and the retrospective nature of questions on child care use allow to cover all the periods considered in the model. Instead, the information on maternal time and child's cognitive outcomes are available only at the year of the survey, i.e., 1997, 2002 or 2007.

The merging procedure between PSID and CDS data has been done exploiting information on the relationship of each CDS child with respect to the head of the household and the primary caregiver (PCG). The final sample is composed by all children aged 0-12 in 1997 without siblings and with both parents living in the household, without missing information on child and parents characteristics and with at least one test score measure. As summarized in table 3.C.2, birth cohorts of children in this sample range from 1984 to 1996, while the terminal period of the model ($T = 13$) corresponds to 1997 for those born in 1984 and to 2009 for those born in 1996.

Table 3.C.3 summarizes the available data for a child born in 1996. This table stresses the existence of long time-gap of missing data due to the structure of the surveys and the timing of the interviews. In fact, while the child care information is available for all periods, data on maternal time and child's cognitive outcomes are available only in the years of the CDS supplement, i.e., 1997, 2002 and 2007.

Table 3.C.4 shows the average characteristics of the sample used for the estimation ($N = 434$) and the total sample of children in CDS, for whom it has been possible to derive information on their parents (3243 observations). This comparison sample includes both families with only one child and families with more children. Mothers in the sample used for the analysis spend less time with their child, work more and use a slightly higher amount of external child care; moreover, they are older and more educated than the mothers in the PSID-CDS data. However, they do not differ in terms of wage at childbirth and race.

3.D. Additional descriptive statistics

See table 3.D.1.

3.E. Robustness checks

The results that have been presented in section 3.6 are robust to several sensitivity analyses that will be described below. For the sake of brevity, I only report the results concerning the parameters for maternal time and external child care time in the CAPF.

3.E.1. Terminal period. The model has been estimated setting $T = 13$. However, looking at figure 3.3, it seems that the child's ability measure increases up to age 12 and starting from this point it becomes flatter. This issue is further confirmed by table 3.E.1, showing that the age at which the child's outcome is maximized is around 12. Then, I re-estimate the model setting $T = 12$. This change yields a sample of 368 observations

Table 3.C.1
Information on availability and sources of data.

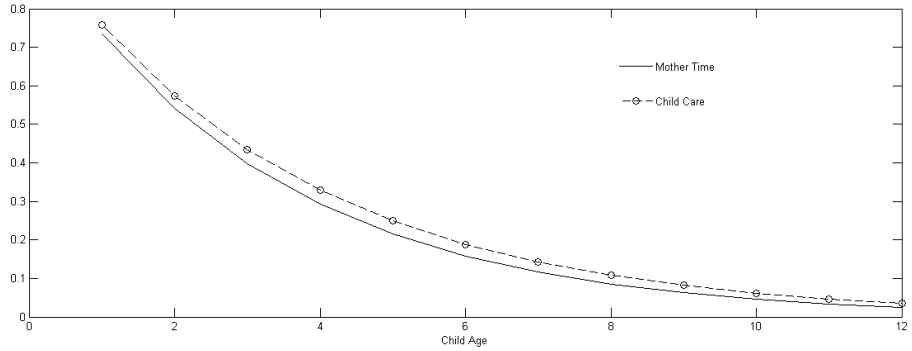
Set of Variables	**Source**	**Survey Years**	**Additional Info**
Non-parental child care	CDS	1997-2002	Retrospective questions on all arrangements used since birth and questions on arrangements used at the time of the survey
Child cognitive outcomes	CDS	1997-2002-2007	Only for children older than 3
Child demographic characteristics	CDS	1997-2002	Time-invariant (except *age*)
Maternal time with the child	CDS-TD	1997-2002	Available only for the year of the survey
Parents' hours of work	PSID	1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1999, 2001, 2003, 2005, 2007	Referred to the year before the survey
Parents' wages	PSID	1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1999, 2001, 2003, 2005, 2007	Referred to the year before the survey
Parents' non labor income	PSID	1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1999, 2001, 2003, 2005, 2007	Referred to the year before the survey
Parents' demographic characteristics	PSID	1997	Time-invariant (except *age*)

Table 3.C.2
Cohorts of children in the final sample.

Year of Birth	Child's Age					
$t=0$	$t=1$	$t=2$	$t=3$	$\cdots$	$t=12=T-1$	$t=13=T$
1984	1985	1986	1987	$\cdots$	1996	1997
1985	1986	1987	1988	$\cdots$	1997	1998
1986	1987	1988	1989	$\cdots$	1998	1999
1987	1988	1989	1990	$\cdots$	1999	2000
1988	1989	1990	1991	$\cdots$	2000	2001
1989	1990	1991	1992	$\cdots$	2001	2002
1990	1991	1992	1993	$\cdots$	2002	2003
1991	1992	1993	1994	$\cdots$	2003	2004
1992	1993	1994	1995	$\cdots$	2004	2005
1993	1994	1995	1996	$\cdots$	2005	2006
1994	1995	1996	1997	$\cdots$	2006	2007
1995	1996	1997	1998	$\cdots$	2007	2008
1996	1997	1998	1999	$\cdots$	2008	2009

repeated for 12 periods.[40] Figure 3.E.1 presents the results, that are very close to the ones presented in section 3.6.

Figure 3.E.1
Productivity parameters for maternal time and child care setting $T = 12$.



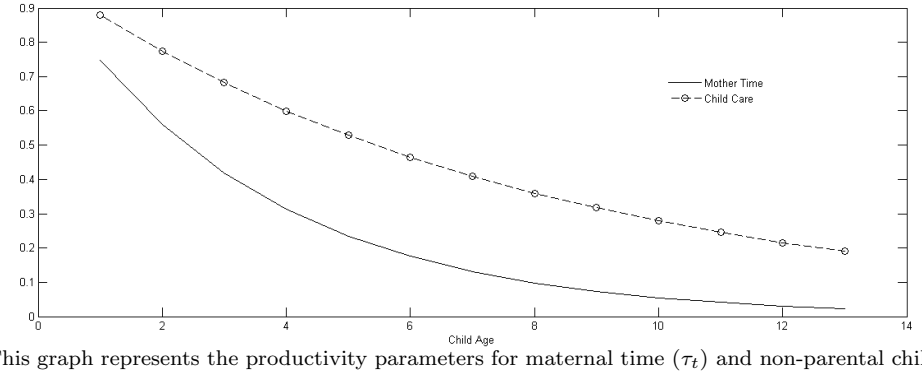
NOTES. This graph represents the productivity parameters for maternal time (τ_t) and non-parental child care (i_t) as a function of child's age $t = 1, 2, \ldots 12$. The final period of the model is $T = 12$.

3.E.2. Definition of maternal time. The variable weekly time with the mother has been defined considering the time spells in which only the mother was present, either being directly involved in child's activities or being just around and not participating. I test the robustness of this choice on two dimensions. First, the category of time when the mother is not actively involved with the child may include housework activities, that may not represent an investment in child's human capital. If this is the case, the estimated coefficient reported in figure 3.8 overestimates the true effect of maternal time. I can test for this issue defining the variable maternal time in such a way that only activities when the mother is directly participating are included. Results are reported in figure 3.E.2: the elasticity of child's development with respect to maternal time is lower than the one found in the main analysis. This suggests that the true effect of maternal time on child's ability may range in between the one found in the main text and the one reported in figure 3.E.2. Second, the definition of the variable in the main analysis does not consider as maternal time the time spells when the mother is involved in child's activities but also the father is present. In order to test whether also the latter category represents an input for child development (meaning that the results shown in figure 3.8 underestimate the true effect), I repeat the estimation of the model defining the variable for maternal time adding also this category. The results shown in figure 3.E.3 do not differ from the ones presented in section 3.6.

3.E.3. Correlation between household income and mother's wage offers. The specification of the mother's wage offer in (3.16) and household income in (3.18) prevents these two components to be correlated. However, it is very likely that mothers in wealthier families receive different wage offers from the market; moreover, a correlation between mother's wage and father's labor income (included in household income) may indicate assortative mating between the two. An easy way to allow these components to be correlated is to include household income as a determinant for the average wage draw

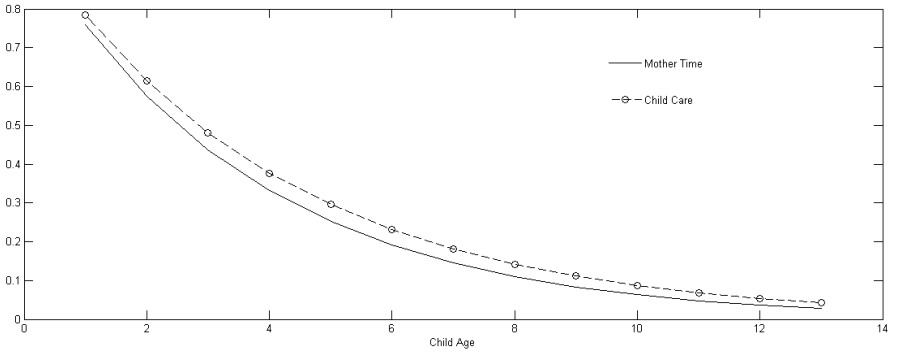
[40]The reduction in sample size is due to observations that have only one test score measure at age 13.

Figure 3.E.2
Productivity parameters for maternal time and child care if maternal time is only active time with the mother.



NOTES. This graph represents the productivity parameters for maternal time (τ_t) and non-parental child care (i_t) as a function of child's age $t = 1, 2, \ldots 13$. τ includes all activities where the mother is actively participating with the child (active time) and excludes the ones where is present but not engaged (passive time).

Figure 3.E.3
Productivity parameters for maternal time and child care if maternal time includes also time when the father is not involved in child's activities but he is around.



NOTES. This graph represents the productivity parameters for maternal time (τ_t) and non-parental child care (i_t) as a function of child's age $t = 1, 2, \ldots 13$. τ includes all time spells when the mother is with the child and also those when the mother is present and the father is around but not involved in child's activities.

the mother receives in each period. Hence, the wage offer described in (3.16) becomes:

$$ln(w_t) = \mu_0 + \mu_1 educ + \mu_2 age_t + \mu_3 age_t^2 + \mu_4 race + \mu_5 I_t + \epsilon_t \tag{3.E.1}$$

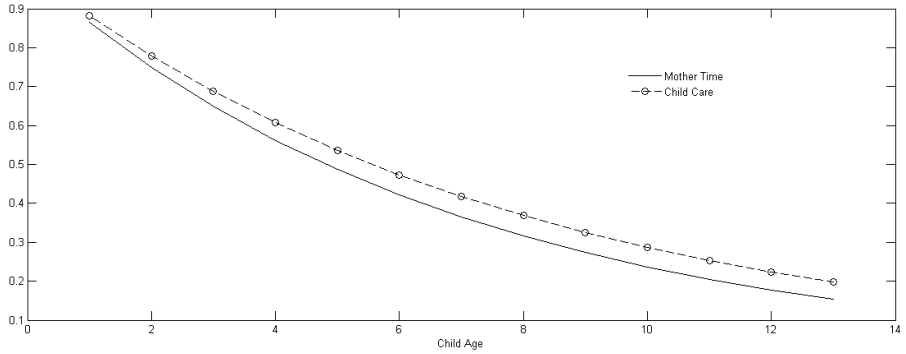
Figure 3.E.4 presents the estimated values of the coefficients for maternal time and external child care and they do not differ from the ones presented in section 3.6.

3.E.4. Specification for child's initial endowment. As pointed out in section 3.4.1, the identification of parameters in (3.20) is hampered by the paucity of test score observations in the available data. This fact is further confirmed by the high standard errors of the estimated parameters, as reported in the panel at the bottom of table 3.6. As a robustness check, I re-estimate the model using a specification of the child's initial endowment depending on more observable characteristics and on less parameters describing the distribution of child's unobserved skills. Equation (3.20) becomes:

$$A_1 = exp(\eta_0 + \eta_1 MotherEdu + \eta_2 FatherEdu + \eta_3 BirthWeight) \tag{3.E.2}$$

where η_0 is a constant and η_3 is an additional parameters to be estimated. Notice that this specification assumes that all children have the same level of unobserved skills. To perform

Figure 3.E.4
Productivity parameters for maternal time and child care allowing household income to affect wages.

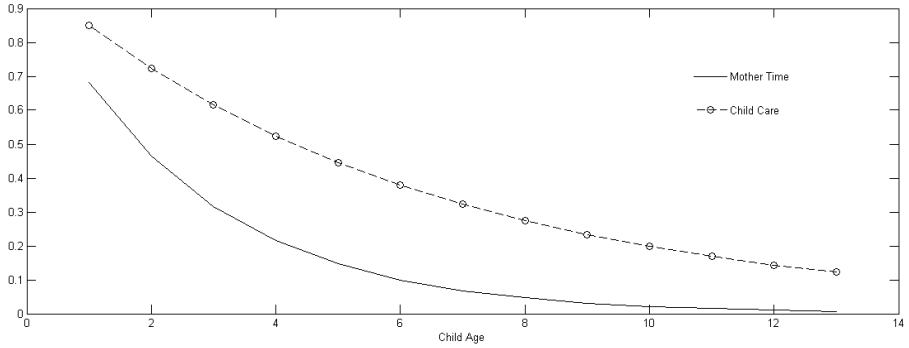


NOTES. This graph represents the productivity parameters for maternal time (τ_t) and non-parental child care (i_t) as a function of child's age $t = 1, 2, \ldots 13$. The wage offer is defined as:

$$ln(w_t) = \mu_0 + \mu_1 educ + \mu_2 age_t + \mu_3 age_t^2 + \mu_4 race + \mu_5 I_t + \epsilon_t$$

where I_t represents household income.

Figure 3.E.5
Productivity parameters for maternal time and child care with a different specification for child's initial endowment.



NOTES. This graph represents the productivity parameters for maternal time (τ_t) and non-parental child care (i_t) as a function of child's age $t = 1, 2, \ldots 13$. The child's initial endowment is defined as:

$$A_1 = exp(\eta_0 + \eta_1 MotherEdu + \eta_2 FatherEdu + \eta_3 BirthWeight)$$

where η_0 is a constant and η_3 is an additional parameter to be estimated. The estimation of this version of the model has been done adding the following statistics to the moment conditions: average score if birth weight is higher than 90 ounces; average score if birth weight is lower than 90 ounces.

this replication, I keep only children without missing data in birth weight, ending up with 340 observations. Moreover, in order to allow the identification of the new parameter η_3, I add to the existing moment conditions the average child's score conditional on the child's birth weight.[41] Results reported in figure 3.E.5 do not differ from the ones presented in section 3.6, even though the productivity coefficient for maternal time is slightly lower.

[41]More precisely, I add the following statistics: average score if child's birth weight is higher than 90 ounces; average score if child's birth weight is lower than 90 ounces (90 ounces correspond to almost 2552 grams). Hence, the number of moment conditions turns to be equal to 105.

Table 3.C.3
Available data for a child born in 1996.

	Child's age (t)													Source	Survey Year
	1	2	3	4	5	6	7	8	9	10	11	12	13		
Non-parental child care	X	X	X	X	X	X	X	X	X	X	X	X	X	CDS	1997, 2002
Child cognitive outcomes						X					X			CDS	2002, 2007
Child demographic charact.	X					X					X			CDS	1997, 2002, 2007
Maternal time with the child	X					X								TD	1997, 2002
Parents' hours of work		X		X		X		X		X				PSID	1999, 2001, 2003, 2005, 2007
Parents' wages		X		X		X		X		X				PSID	1999, 2001, 2003, 2005, 2007
Parents' non labor income		X		X		X		X		X				PSID	1999, 2001, 2003, 2005, 2007
Parents' demographic charact.	X		X		X		X		X					PSID	1997, 1999, 2001, 2003, 2005, 2007

Table 3.C.4
Mean characteristics of the sample with respect to PSID-CDS data.

	PSID-CDS	Sample	T-test
Mother's hours of work	23.59	27.12	−10.69***
	(0.14)	(0.29)	
Non-parental child care	12.21	14.68	−9.34***
	(0.10)	(0.24)	
Maternal time with the child	25.83	21.06	6.34***
	(0.32)	(0.68)	
Mother's wage before childbirth[a b]	10.98	11.24	−1.25
	(0.09)	(0.18)	
Mother's education	12.98	13.25	−7.23***
	(0.02)	(0.03)	
Mother's age at child's birth	26.98	28.17	−15.77***
	(0.04)	(0.07)	
Mother's race: white	0.61	0.61	0.35
	(0.00)	(0.01)	
Father's hours of work	38.66	45.22	−30.22***
	(0.11)	(0.19)	
Father's education	12.66	13.27	−16.98***
	(0.01)	(0.03)	
Household non labor income[a]	16.86	12.79	2.50**
	(1.39)	(0.84)	
N	3243	434	

[a] Monetary variables deflated into 1997 US$.
[b] Mother's wage before childbirth refers to the year before the child was born.

Table 3.D.1
Descriptive statistics on LW raw test scores, by child's age and by subgroups.

Child's age	4-5	6-10	11-13
All Sample ($N = 434$)	6.70	30.05	44.84
	(4.13)	(11.68)	(6.23)
Female	6.88	30.69	45.23
	(3.97)	(11.18)	(5.65)
Male	6.53	29.40	44.47
	(4.31)	(12.18)	(6.76)
Non-White	7.26	30.16	43.10
	(4.10)	(11.19)	(6.42)
White	6.32	29.98	45.93
	(4.15)	(12.05)	(5.86)
Mother Education:	7.24	31.86	43.39
years of schooling> 12	(4.44)	(11.62)	(5.60)
Mother Education:	5.62	27.71	43.24
years of schooling= 12	(3.44)	(11.19)	(6.52)

Table 3.E.1
OLS estimates of LW raw score on child's age.

Dep. Var. LW raw score		
Child's Age	18.195***	18.163***
	(1.883)	(1.829)
Child's Age Squared	−0.764***	−0.762***
	(0.097)	(0.095)
Controls		
Maternal Time	X	X
Child Care Time	X	X
Household Income	X	X
Mother Education		X
Father Education		X
N	195	195
Child's age maximizing the outcome		
	11.90	11.92

NOTES. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at child level. The age maximizing outcome (last row) is computed setting $\frac{\partial LW score}{\partial t} = 0$.

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