Evaluating Early Childhood Policies: An Estimable Model of Family Child Investments

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Abstract

In this paper, I develop and estimate a technology of skill formation nested within a collective model of household behavior to evaluate the effect of various early childhood interventions. The model incorporates different channels of parental investments in children such as time, material investments, and childcare services. I estimate the model in a novel dataset from Chile and evaluate the effects on child development of three policies currently operating in the country: cash transfers, childcare subsidies, and subsidies to child-specific goods. In Chile, as is common in various countries implementing cash transfers to poor households, women are the recipient of cash transfers in bi-parental households with the idea that cash in the hands of women translate into better child outcomes. To allow for different outcomes depending on the recipient of cash transfers, in the model, household decisions are the outcome of a bargaining process between parents with different preferences. I find that cash transfers to women have limited effect on their bargaining power and that subsidies to child-specific goods are much more effective than childcare subsidies or cash transfers. Childcare subsidies increase female labor force participation but do not raise significantly skills of children.

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1   Introduction

Research in medicine, psychology, and economics shows that skills shaped during the first years of life have significant consequences for adult life outcomes. [1] This have motivated a large number of policies aimed at enhancing the skills of children in disadvantage. However, we still have no certainty about what are the most cost-effective policies to close the gaps of skills between rich and poor children. Furthermore, although the question of what are the key inputs and the most sensitive periods of child skills formation has been asked previously in the literature[2], family investments have been proved to be key inputs in the skills production function, and they might react as a consequence of introducing new policies. The goal of this paper is to asses which policies are most effective to close the gaps in skills between rich and poor children, taking into account that family investments change as a consequence of public policy.

To analyze how early childhood policies affect resources allocated to children and skill formation, I develop and estimate a skill production function nested within a collective model of household behavior. In the dynamic model, parents care about the skills of their child and make investments to increase the stock of skills. Such investments can take the form of time investments -such as playing, reading, or signing to the child-, material investments -toys, puzzles, music or adequate food, among others- and childcare services.

Family investments in children might react as a consequence of introducing child development policies. Moreover, there is no reason to believe that all family members will react in a similar manner. Cash transfers to children with two parents present in the household, for example, are often targeted to women with the idea that cash in the hands of women might translate into better child outcomes than cash in the hands of men. Additionally, childcare subsidies might have a stronger effect on female rather than male labor supply. To allow policies to have different effects in household members, I allow parents to have different preferences in the model. The allocation of parental investments in child skills - a public good- is mediated by each member's preferences and their relative bargaining power.

I estimate the model using a novel dataset from Chile and use it to evaluate the effects of three policies currently implemented in the country to promote skills of children in disadvantage: cash transfers, childcare subsidies, and subsidies to child-specific good - goods that are specifically useful for child development such as puzzles, nutritional supplements for children, among others. I find that subsidies for child-specific goods are the most cost-effective way to increase skills for children in disadvantage. Childcare does not seem to be a very effective way to promote skills, probably because of the quality of the average childcare provider. However, these policies do liberate time resources that family members can use to participate in the labor market, specially women. Cash transfers have also limited effects on skill for children as only a small fraction of it is actually invested in child development. I find that, although women have

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[1]For a review, see Conti and Heckman (2012).

[2]See, for example, Todd and Wolpin (2007), Cunha, Heckman, and Schennach (2010), Chetty et al. (2011), and J. Heckman and Mosso (2014) for a review.

stronger preferences for children, cash transfers have a very limited effect in the process of decision making within the household. For such a reason, switching the recipients from mothers to fathers would have limited effects on the process of child development.

There are few papers estimating structural models of household behavior and child outcomes with the goal of understanding how family behavior affects child skill formation (Bernal, 2008; Del Boca, Flinn, & Wiswall, 2014; Gayle, Golan, & Soytas, 2015; Griffen, 2018; Chan & Liu, 2018). This is the first paper that empirically evaluates a collective model of household behavior and child investments incorporating decisions of time investments, monetary investments and childcare-preschool services. Taking into account these three channels of investments is relevant since we are able to asses how each policy affects different dimensions of parental investments in their children. The results of this paper allow us to have a better idea of what policies are most effective in promoting skills of young children and the mechanisms through which each policy affects such a process.

By modeling household behavior through the collective approach, parents are allowed to have different preferences. Incorporating the collective model of household behavior in the process of skills formation for children is a relevant contribution for various reasons. First, modeling household behavior through the collective approach has proven to result in better empirical predictions than the unitary framework (Chiappori & Donni, 2009). Second, from a policy perspective, it is common to see interventions targeting individual household members. For instance, most cash transfer programs in developing countries state as an explicit condition that, in households with children, mothers should be the sole recipients of such subsidies (Fiszbein, Schady, & Ferreira, 2009). It is often argued that mothers have stronger preferences for meeting the needs of children and therefore cash in the hands of mothers translates into better child outcomes (Blundell, Chiappori, & Meghir, 2005). Moreover, the empirical regularity that there is a positive correlation between women's empowerment and child development (Haddad, Hoddinott, Alderman, et al., 1997) cannot be explained by considering the household as a single entity with one utility function. The collective approach provides a framework that allows us to assess the extent to which targeting individual members as beneficiaries of policies, such as cash transfers, actually have consequences on child development. Furthermore, it provides an ideal framework to test the effects of female empowerment on child development.

The dataset used in this paper is the Early Childhood Longitudinal Survey from Chile (ECLS). This dataset contains detailed information regarding the skill formation process in children and allows me to overcome some empirical limitations that the literature has previously faced. For instance, studies have shown that parental skills largely determine children's skills (J. Heckman & Mosso, 2014). By having information on parental IQ tests and personality assessments, I am able to incorporate parental skills into my estimation strategy. Additionally, we know that there is a multiplicity of skills that are relevant to determining adult life outcomes (Cunha et al., 2010). I incorporate multiple measures of skills across various dimensions, such as motor, communication, cognitive and behavioral abilities in children. Additionally, the dataset contains detailed

information about the time and material investments that parents make in their children, such as the weekly frequency with which each parent reads to the child, or the availability of toys, books for children and the consumption of different types of foods. This allows me to incorporate the quantity and quality of investments that families make in their children.

Moreover, this is the first paper in the literature of household choices and child development that estimates a technology of skill formation through a dynamic latent-factor approach a-là Cunha et al. (2010). This allows me to obtain non-parametric identification of the skill production technology by using a large number of skill measures. Because of that, the results of the estimation are less sensitive to the specific parametric form assumed for the skill formation technology, and the bias arising from measurement error is reduced, making the results more robust. This, along with the fact that a latent factor structure can be interpreted as unobserved heterogeneity (Carneiro, Hansen, & Heckman, 2003) and potentially improves the accuracy of the estimates, has made factor analysis a popular tool to get accurate estimates of the skill production function (Cunha et al., 2010; Cunha & Heckman, 2008; J. J. Heckman, Stixrud, & Urzua, 2006). This paper is the first to estimate the production function of skills via a latent-factor approach, nested within a collective model of household behavior. This paper also makes a methodological contribution to the estimation of dynamic microeconomic models with unobserved and continuous state variables. By implementing an efficient simulation-based estimator using particle filtering techniques (Murphy, 2012; Creal, 2012), I propose a feasible computational approach for dealing with the high dimensionality integration problem that arises in such models.

In this paper, I propose a new estimation strategy for collective models of household behavior. The collective model of household behavior assumes that parents have different preferences and the final allocation of resources is a Pareto efficient outcome. The extent to which the final outcome follows preferences of each member depends on the Pareto weight, or bargaining power, of each member. Traditionally, empirical applications of the collective model use data on goods that are assumed to be of private consumption such as gender specific clothing or personal care items (Cherchye, De Rock, & Vermeulen, 2012; Blundell et al., 2005). This approach imposes certain assumptions on the behavior of families such as that one member does not care about the consumption level of other members on such goods. For instance, a husband would be indifferent about the consumption level on personal care of his wife. Additionally, it assumes that the intra-household bargaining process can be fully explained by observing the consumption of such items. This approach fails in the presence of measurement error or when there are more elements in the bargaining process in addition to the goods observed to the econometrician. Rather than using information on private consumption, I use answers to questionnaires related to female empowerment and gender roles within the household, such as who makes decisions about how to spend the income. Through a latent factor approach estimation, I use these answers as noisy measures of the bargaining power of each member. This approach allows for unobserved heterogeneity, measurement error, and does not rely on the assumption that the

whole bargaining process is explained by the consumption of specific elements considered to be of private consumption.

The data from test scores show significant large gaps in skills between rich and poor children at age 5. The skill gap between children in the lowest quintile of the income distribution and children in the highest quintile, is in between 0.3 and 0.7 standard deviations in tests measuring cognitive abilities, socio-emotional development, and vocabulary skills, among others. These inequalities are mostly explained by differences in parental skills and monetary investments. Additionally, the model parameter estimates show that fathers' time spent with children is 50% as productive as mothers' time and that mothers have stronger preferences for children.

When analyzing which policy is more effective for child skills formation, it is not clear *a priori* which one would be more effective: cash transfers, childcare subsidies, or subsidies for material investments. Cash transfers allow parents to spend the money freely: there is no guarantee that they will do it in the way that is most effective for children, as they might decide to spend it on elements of private consumption. Cash transfers could also increase time investments from parents, depending on the extent to which cash transfers decrease labor force participation. Childcare subsidies could potentially expose children to a better suited environment for skill promotion. However, there is evidence from Latin America pointing out that such centers can have negative effects on child skill formation (Behrman, Cheng, & Todd, 2004; Bernal, Fernández, Flórez, Gaviria, et al., 2009; Rosero Moncayo, Oosterbeek, et al., 2011). Childcare subsidies could also increase female labor force participation, further decreasing the amount of time that parents spend with their children. Finally, subsidies to child investments are guaranteed to end up being used for skill formation purposes. However, it is unclear how effective they are when compared to other inputs such as parental time or childcare services.

Regarding the targeting aspect of cash transfers, the extent to which children would benefit more by having mothers as beneficiaries is also unclear. This depends on how effective cash transfers are in empowering women in households, how different are preferences for child skills between parents, and also on the marginal willingness to pay for skills from each parent. This last point is related to the fact that both parents need to make private investments of time and money for child skills. However, skills are ultimately a public good, since both parents get benefits from it. The extent to which each member contributes to skill formation in children depends on the marginal willingness to pay. For instance, even if fathers cared less for their children, they might be at a relatively low level of marginal utility of consumption such that for each additional dollar earned, most of it would end up in children investment.

The results of the counterfactual policy analysis suggest that, taking into account the aforementioned features about the three different programs considered, subsidies for child-specific investments are the most effective way to promote child development. At any point, they provide the highest marginal return, implying that the optimal policy would not be a mixture between programs but rather devoting all resources to such a policy.

The remainder of this article is structured as follows: In section 2 I introduce a collective model

of household behavior and child skill formation. I describe the data in Section 3. I discuss the estimation and identification of the economic model in Section 4. The main results of the paper are included in Section 5 and finally I conclude in Section 6.

2 A Collective Model of Household Behavior and Child Outcomes

In this section I describe the economic model used to rationalize investments in children together with household behavior. Each household, indexed by (h), is composed of two agents (j), namely the father (f) and the mother (m). In each household, there is also one child[3] with a level of skills denoted by (s), who is not a decision maker.[4] There are two periods t in the model corresponding to age 3 of the child $(t=1)$ and age 5 $(t=2)$. In each period, parents make decisions of monetary investments for the child (I_t) and private consumption (c_t^j). Additionally, parents decide how much effort to invest in the quality of the interactions with their child (e_t^j). I use a measure of quality of interactions to acknowledge the fact that it is not only time investments in children what will ultimately affect their skills but also the nature of their interactions. e_t^j is thus a measure of time adjusted for quality of interactions between parent j and child in period t. The effort, monetary investments, and consumption decisions can take any positive real value $(e_t^j, c_t^j, I_t) \in \mathbb{R}^+$. Additionally, parents decide wether or not to participate in the labor market $(h_t^j) \in \{0,1\}$[5]. During the first period, parents need to decide whether or not use childcare services (a_t) and then a_t can take the value of zero or one depending on whether the child goes or not to these services. The utility function for parent j for the first period is described in Equation 1:

$$u_1^j(c_1^j, h_1^j, e_1^j, d_1^j, s_1) = \alpha_{1,1}^j \ln(c_1^j) + \alpha_{2,1}^j \ln(s_1) - \alpha_{3,1}^j(h_1^j) - \alpha_{4,1}^j e_1^j -$$

$$\alpha_{5,1}^j e_1^j h_1^j - \alpha_{6,1}^j h_1^j(1-a_1) + \sum_{m=0}^{3} q_{1,m}\varepsilon_{1,m} \qquad (1)$$

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[3]I include only one child in the economic model as allowing for multiple children in the economic model would imply solving additional questions that are not the main goal of this paper. For instance, I would need to identify or take a stance on whether parents have the same preferences for boys and girls, or whether they have preferences for equality of skills among children, as opposed to devoting more resources to the most promising child. Moreover, I would also need to take a stance as to what extent there is a quality-quantity tradeoff in fertility decisions: do parents prefer to have more children and devote fewer resources to each of them or to terminate their childbearing early and devote most resources to a limited number of children.

[4]The assumption of having the child not as a decision maker is common in the literature (Del Boca et al., 2014; Bernal, 2008). That seems reasonable given the little influence that children under six years of age can have on the resource allocation of the household.

[5]The assumption that labor market participation is made only at the extensive margin is reasonable for the case of Chile since there is very low incidence of part-time work: the distribution of hours worked is unimodal for men and bimodal for women around zero and 45 hours a week. I provide evidence of this in the online appendix, in Section A and Figure A.1. Additionally, unemployment levels are very low compared to international standards, at about 5%.

As seen in the utility function, parents care about consumption (c_1^j), skills of the child (s_1) and leisure $(1 - h_1^j)$. Moreover, providing quality-time investments in children is costly and is costlier for parents who participate in the labor market, by the term $(\alpha_{5,1}^j e_1^j h_1^j)$, as time resources become scarcer. The term $-\alpha_{6,1}^j h_1^j(1 - a_1)$ reflects the fact that childcare can liberate time resources and thus it might be less costlier for parents to participate in the labor market. Finally, the last term is preference shock associated to each combination of labor supply and childcare decision: ε_{t,d_t^j} where d_t^j indicates the action taken by agent j according to the following mapping:

$$
d_1^j = \begin{cases} 0 & \text{if } h_1^j = 0 \text{ and } a_1 = 0 \\ 1 & \text{if } h_1^j = 1 \text{ and } a_1 = 0 \\ 2 & \text{if } h_1^j = 0 \text{ and } a_1 = 1 \\ 3 & \text{if } h_1^j = 1 \text{ and } a_1 = 1 \end{cases}
$$

There is no uncertainty for individuals about the preference shocks. $q_{1,m}$ is an indicator function if decision m is taken. That is: $q_{1,m} := \mathbb{1}\{d_1^j = m\}$ where $\mathbb{1}\{\}$ is the indicator function taking the value of 1 if the statement inside $\{\}$ is true and zero otherwise. The coefficients of Equation 1 are normalized so that their sum is equal to one.

Preferences for the second period are represented in the utility function represented in Equation 2:

$$
u_2^j(c_2^j, h_2^j, e_2^j, d_2^j, s_2) = \alpha_{1,2}^j \ln(c_2^j) + \alpha_{2,2}^j \ln(s_2) - \alpha_{3,2}^j(h_2^j) - \alpha_{4,2}^j e_2^j - \alpha_{5,2} e_2^j h_2^j + \sum_{m=0}^{1} q_{2,m} \varepsilon_{2,m} \tag{2}
$$

Note that parents do not make decisions about preschool/daycare during the second period, when children are five years old[6]. This implies that in the second period there is no decision regarding preschool/childcare attendance, $d_2^j = h_2^j$.

Skills of the child in period t, (s_t), are a function of monetary investments (I_t), quality-time investments from both parents (e_t^j), preschool attendance (a_t), the skills of the child's primary caregiver (PG), which are constant over time[7], the previous level of skills (s_{t-1}) and the age of the child in months (τ_t). I allow for unobserved heterogeneity in the production of skills denoted by $(\eta_{s,t})$. The production of skills is specified in the following Equation 3:

$$
s_t = r_t s_{t-1}^{\theta_0} \tilde{I}_t^{\theta_1} e_t^{\theta_2} \tag{3}
$$

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[6]Five year olds children all attend to preschool services in our sample.

[7]There is evidence pointing to the fact that cognitive skills remain stable at around age 8 and non-cognitive skills are stable during adult life (Borghans, Duckworth, Heckman, & Ter Weel, 2008; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). For this reason, assuming that skills of adult members are stable is reasonable.

where r_t is the total factor productivity given by:

$$r_t = \underbrace{\exp\left(\delta_0 + \delta_1 \tau_t + \delta_2 a_t + \delta_{3,t} PG + \delta_4 Members_t + \eta_{s_t}\right)}_{\text{Total Factor Productivity}} \tag{4}$$

The variable $Members_t$ denotes the number of household members present in period t in the household. This captures the idea that, by having additional household members, not only might the production of skills be affected but also the productivity of each input. e_t is the quality-time investments in the child, given by the production function:

$$e_t = \underbrace{\left[\gamma_0 \left(\tilde{e}_t^f\right)^\phi + \gamma_1 (\tilde{e}_t^m)^\phi\right]^{1/\phi}}_{\text{Total effective time investment}} \tag{5}$$

where $\tilde{e}_t^j = e_t^j \exp\left(\eta_{e_t^j}\right)$ and $\tilde{I}_t = I_t \exp(\eta_{I_t})$. The terms $\eta_{e_t^j}$ and η_{I_t} are unobserved heterogeneity. This term captures the fact that parents can differ in unobserved ways in how productive they are in terms of the time and monetary investments in their children. That is, even with the same amount of effort and monetary investment, I allow the productivity of these inputs to be different across households. The production function of quality-time investments in Equation 5 allows to some degree of substitutability between paternal and maternal effort given by the elasticity of substitution $\frac{1}{1-\phi}$ and different relative productivities (γ_1, γ_2).

2.1 Household's problem

As stated previously, parents make decisions for two periods, when the child is three and five years old. After the two periods, children enter a different stage in which parents and children face a different set of incentives in the process of skills production. Parents face a different set of incentives given that children start the formal schooling years and start behaving more as agents making their own decisions, which might have consequences for their own skills. For this reason, I only model childhood lasting for two periods: when children are three years old and when they are five years old[8]. The value of the household's problem at the beginning of the second period is given by:

$$V_2(\Psi_2) = \max_{\{I_2, \{c_2^j, e_2^j, h_2^j\}_{j=m,f}\}} \mu_2 u_2^f(c_2^f, h_2^f, e_2^f, d_2^f, s_2) + (1 - \mu_2) u_2^m(c_2^m, h_2^m, e_2^m, d_2^m, s_2) \tag{6}$$

where, again, monetary and quality-time investment, as well as consumption decisions can take any positive real number $(I_2, c_2^j, e_2^j,) \in \mathbb{R}^+$ and the labor participation decision is done at the

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[8]This assumption is commonly made in the literature. Bernal (2008) assumes that early childhood relevant decisions are made until age 5. Del Boca et al. (2014) model household behavior until children are 16 years old but only use information on two periods to estimate their model, that is, when children are on average four and nine years old.

extensive margin $h_2^j \in \mathbb{R}$. $\mu \subseteq [0,1]$ represents the Pareto weight or bargaining power of the father, which is normalized to be between zero and one. I impose a parametrization of the Pareto weight commonly used in the literature[9] given by:

$$\mu_t(E_t) = \frac{\exp(\Lambda' E_t + v_{\mu_t})}{1 + \exp(\Lambda' E_t + v_{\mu_t})} \tag{7}$$

where $\Lambda \in \mathbb{R}^L$ is a vector of coefficients; E_t are variables affecting the the relative bargaining power of each member in the household; and $v_{\mu,t}$ is unobserved heterogeneity. In the E_t variables, I include the ratio of offered wages, the difference in ages between spouses, the difference in grades of schooling and the father's share in non-labor income. Additionally, I include conditions of the local labor market, which include the relationship between male and female unemployment, the sex ratio and the wage ratio in the region of residence of the household. Similar specifications to this one have been used previously in the literature.[10]

$$E_t = \left[\frac{w_t^f}{w_t^m}, \frac{Y_t^f}{Y_t^f + Y_t^m}, age_t^f - age_t^m, yrschool_t^f - yrschool_t^m, \frac{\bar{Female_t}}{\bar{Male_t}}, \frac{U^{Male_t}}{U^{Female_t}}, \frac{w^{Male_t}}{w^{Female_t}} \right] \tag{8}$$

where w_t^j denotes the wage offer for member j, Y_t^j denotes non-labor income in the hands of member j. Elements in Y_t^j include transfers from family members, cash transfers, and financial returns, among others. age_t^j is the age of each member and $yrschool_t^j$ is the maximum grade of schooling attained. $\frac{\bar{Female_t}}{\bar{Male_t}}$ is the sex ratio in the region of residence of the household, $\bar{U}$ denotes the unemployment rate for each gender, and $\frac{w^{Male_t}}{w^{Female_t}}$ is the wage ratio between women and men in the region of residence. These variables are what the literature refers to as distribution factors, variables that affect the behavior of the household only through its effect on the bargaining power.

The solution for the problem of the household should satisfy the technological constraint given in 3, the time constraint for each agent: $h_2^j \in \{0,1\}$, for $j = m, f$ and non-negativity constraint:

$$c_2^f, c_2^m, I_2, e_2^f, e_2^m \geq 0,$$

and the budget constraint

$$c_2^f + c_2^m + P_{I,2} I_2 + P_{a,2} = Y_2^f + Y_2^m + w_2^m h_2^f + w_2^f h_2^f + \Xi_2 \tag{9}$$

where w_2^j represents the wage offer for individual j, Y^j is the corresponding non-labor income, and Ξ_2 is the total non-labor income that cannot be attributed to any specific household mem-

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[9]See, for instance (Cherchye et al., 2012), Bruins (2015) and Browning, Chiappori, and Lewbel (2013).

[10]Again, this determinant of bargaining power has been previously used in the literature (Cherchye et al., 2012), Bruins (2015) and Browning et al. (2013).

ber.[11] $P_{I,2}$ is the price of monetary investments in children for the second period. Note that in the second period parents do not make decisions regarding childcare attendance so they have to pay price of preschool[12]. The state space Ψ_2 is given by:

$$\Psi_2 = \{r_2, s_1, \eta_2, \Xi_2, \mu_2, \{Y_2^j, w_2^j, \epsilon_2^j\}_{j=m,f}, P_{I,2}\} \tag{10}$$

where the vector η_2 collects the unobserved heterogeneity: $\eta_t = \{\eta_{I_t}, \eta_{e_t^f}, \eta_{e_t^m}, \eta_{s_t}\}$ and ϵ_2^j is the two-dimensional vector of preference shocks for agent j. The problem of the household during the first period is given by:

$$V_1(\Psi_1) = \max_{\{I_1, a_1, \{c_1^j, e_1^j, h_1^j\}_{j=m,f}\}} \mu_1 u_1^f(c_1^f, h_1^f, e_1^f, d_1^f, s_1) + (1-\mu_1)u_1^m(c_1^m, h_1^m, e_1^m, d_1^m, s_1) +$$

$$\beta \, \mathbb{E}_{f_{\eta_2}}[V_2(\Psi_2) \mid \Psi_1] \tag{11}$$

subject to the skill production technology given in 3, the non-negativity constraint:

$$c_1^f, c_1^m, I_1, e_1^f, e_1^m \geq 0,$$

and the budget constraint:

$$c_1^f + c_1^m + P_{I,1}I_1 + P_a a = Y_1^f + Y_1^m + w_1^m h_1^f + w_1^f h_1^f + \Xi_1 \tag{12}$$

The expectation is taken with respect to the distribution of heterogeneity in the second period: $\eta_2 = \{\eta_{I_2}, \eta_{e_2^f}, \eta_{e_2^m}, \eta_{s_2}\}$. The state space in the first period is given by:

$$\Psi_1 = \{r_1, s_0, \eta_1, \Xi_1, \{\epsilon_1^j, Y_1^j, w_1^j\}_{j=m,f}, P_a, P_{I,1}, \mu_1, \mu_2\} \tag{13}$$

where ϵ_1^j is the four-dimensional preference shock for agent j and s_0 corresponds to skills in period zero, which is interpreted as health at birth. Note that both, μ_1 and μ_2 are included as part of the state space as I assume that both parents know their relative bargaining power in both periods. Given that I do not include the problem of commitment in the relationship -the possibility of dissolving the union[13]- I allow agents to be able to have complete information regarding the bargaining power today and tomorrow[14].

I allow for cost-shifters for the price of childcare and of monetary investments in children. Specifically, the price of childcare depends on the distance to the nearest childcare provider. The

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[11] Examples of elements included in the Ξ_2 term are subsidies for water consumption for the household.

[12] The price that families pay include not only tuition fees, which in most cases is zero, but also incorporates other costs such as transportation.

[13] The commitment problem is part of the main point of the paper. Such question has been explored previously in the literature. See for instance, (Tartari, 2015).

[14] Note that an equivalent formulation of the problem will be to have only one Pareto weight valid for the two periods but where it is discounted for the second period

price of monetary investments depends on the relative supply of childcare centers in the household's neighborhood. Neighborhoods with a relatively large supply of such centers could, in principle, offer relatively larger supply of other types of goods or services for children and thus, could shift the cost of such investments. The prices are determined by the following specification:

$$P_a = \text{Pchildcare}_{a,0} + \text{Pchildcare}_{a,1}\text{DChildcare} \tag{14}$$

$$P_{I,t} = \text{Price}_{I,0} - \text{Price}_{I,1}Dens_t \tag{15}$$

where *DChildcare* is the distance to the nearest preschool provider, in meters, and $Dens_t$ is the number of preschool/daycare providers within 5km of the household[15].

2.2 Model solution

The model involves a set of discrete choices -childcare and labor supply- together with continuous decisions such as monetary investments in children, effort that parents invest in their children, and consumption. I solve the model in two steps. First, I find the optimal decisions of investment, consumptions, effort, and monetary investments, for a given level of labor supply-childcare decisions. Define x_t as the vector of continuous decisions in period t:

$$x_t = \{c_t^f, c_t^m, e_t^f, e_t^m, I_t\} \tag{16}$$

$x_t^*(h_t^f, h_t^m, a; \Psi_1)$ is a vector containing the optimal decisions of consumption, effort, and investments, for a given level of labor supply and childcare decisions. For instance, for the first period, we can define:

$$x_1^*(h_1^f, h_1^m, a_1; \Psi_1) = \max_{\{I_1, \{c_1^j, e_1^j\}_{j=m,f}\}} \mu_1 u_1^f(c_1^f, h_1^f, e_1^f, d_1^f, s_1) + (1 - \mu_1)u_1^m(c_1^m, h_1^m, e_1^m, d_1^m, s_1) +$$

$$\beta \mathbb{E}_{f_{\eta_2}}[V_2(\Psi_2)|\Psi_1] \tag{17}$$

where $x_1^*(h_1^f, h_1^m, a_1; \Psi_1)$ contains the optimal decisions of consumption, effort, and monetary investments in the first period conditional on labor supply and childcare decisions:

$$x_1^*(h_1^f, h_1^m, a_1; \Psi_1) = \{c_1^{f,*}(h_1^f, h_1^m, a_1; \Psi_1), c_1^{m,*}(h_1^f, h_1^m, a_1; \Psi_1), e_1^{f,*}(h_1^f, h_1^m, a_1; \Psi_1),$$

$$e_1^{m,*}(h_1^f, h_1^m, a_1; \Psi_1), I_t^*(h_1^f, h_1^m, a_1; \Psi_1)\} \tag{18}$$

subject to the the technology of skills formation 3, non-negativity constraint of investments and consumption, and the budget constraint 9. These analytical solutions are presented in section B

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[15]Section D of the Online appendix provides evidence suggesting that the these measures modify the price of childcare and investments in children.

of the Online Appendix. We define the value of the problem conditional on labor supply and childcare decisions as:

$$\tilde{V}_1(h_1^f, h_1^m, a_1; \Psi) = \max_{x \in R^{5+}} \mu_1(\Psi) u_1^f(x_1, h_1^f, h_1^m, a_1, s_1; \Psi_1) + (1 - \mu_1(\Psi_1)) u_1^m(x_1, h_1^f, h_1^m, a_1, s_1; \Psi_1) +$$

$$\beta \, \mathbb{E}_{f_{\eta_2}} \left[V_2(\Psi_2, x_1, h_1^f, h_1^m, a_1, s_1) \mid \Psi_1 \right] \tag{19}$$

This allows me to find the optimal decisions of labor supply and childcare:

$$\left(h_1^{*,f}(\Psi_1), h_1^{*,m}(\Psi), a_1^*(\Psi) \right) = \arg \max_{h_1^f, h_1^m, a_1 \in \{0,1\} \times \{0,1\} \times \{0,1\}} \tilde{V}(h_1^f, h_1^m, a_1; \Psi) \tag{20}$$

and the value of the household problem is:

$$V_1(\Psi_1) = \tilde{V}_1(h_1^{*,f}(\Psi_1), h_1^{*,m}(\Psi_1), a_1^*(\Psi_1); \Psi_1) \tag{21}$$

I have presented the solution for the first period. The solution for the second period follows a very similar approach. Given the dynamic nature of the model, I first solve for the solutions in the second period and then I solve for the first period[16].

2.3 Evaluating the Effects of Policies on Child Development

The model developed in the previous section is rich enough to consider several mechanisms through which government policies might affect children's skills. Consider, for example, the case of cash transfers given to mothers. This policy expands the budget of the household, and so the family might potentially invest more monetary resources in goods useful for child development. However, the extent to which the cash transfer translates into more investment for children depends on each parent's preferences on the skill formation process, and on how the bargaining power of each member changes as a consequence of this policy. Moreover, labor supply, time investments, and childcare attendance decisions might also be affected as a consequence of this policy. The model is flexible enough to capture these effects of a cash transfer.

To illustrate how this model can be useful for policy evaluation, I simulate the effect of four policies and estimate the relative efficiency of each of them in the process of child skill formation. The policies analyzed are unconditional cash transfers given to fathers, cash transfers given to mothers, subsidies for childcare, and subsidies to monetary investments in children.

Consider, the effect of a cash transfer q_1^m given to the mother during the first period. This policy is modeled as an increase in the non-labor income of the mother in the following way:

$$Y_1^{m,\text{new}} = Y_1^{m,\text{old}} + q_1^m \tag{22}$$

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[16]The algebraic details of the solutions for each variable are presented in the online appendix.

The new state space is affected as a consequence of such a policy first, by the direct effect on non-labor income, and second by the effect on the bargaining power μ_1^{new}. How much does non-labor income affect bargaining power is determined in Equation 7:

$$\mu_1^{\text{new}} = \mu_1(E_1^{\text{new}}) = \frac{\exp(\Lambda' E_1^{\text{new}} + v_{\mu_1})}{1 + \exp(\Lambda' E_1^{\text{new}} + v_{\mu_1})}$$

where one of the elements in E_1^{new} is $\frac{Y_t^f}{Y_t^f + Y_t^{m,\text{new}}}$. The new state space, after the policy is implemented, will be given by:

$$\Psi_1^{\text{new}} = \{r_1, s_0, \eta_1, \Xi_1, \{\epsilon_1^j, Y_1^{j,\text{new}}, w_1^j\}_{j=m,f}, P_a, P_{I,1}, \mu_1^{\text{new}}, \mu_2\} \tag{23}$$

The change in the state space will affect household decisions. With a new level of maternal income and bargaining power, households will possibly have different levels of consumption, labor supply, effort, and investment levels. For instance, if mothers have stronger preferences for the children's skills, more non-labor income for the mother might translate into more material and monetary investments for the child as the policy shifts the bargaining power towards the mother in addition to increasing the household's budget.

Now, to see how skills of the child change as a consequence of such a policy, we need to analyze how the process of skill formation is affected by the changes in households decisions. Consider the effect of cash transfers in children's log-skills using the technology of skills formation presented in Equation 3. The effect of the policy on skills is given by how each input (childcare attendance, monetary investments, and quality-time investments) changes as a consequence of the policy, and the relative productivity of each input (r_1, θ_1, θ_2):

$$\Delta_{s,1}^{Y_1^m} = \ln(s_1^{\text{new}}) - \ln(s_1^{\text{old}})$$

$$= \underbrace{\ln\left(\frac{r_1(a_1^{\text{new}})}{r_1(a_1^{\text{old}})}\right)}_{\text{Effect on childcare attendance}} + \underbrace{\theta_1 \ln\left(\frac{\tilde{I}_1^{\text{new}}}{\tilde{I}_1^{\text{old}}}\right)}_{\text{Effect on monetary investments}} + \underbrace{\theta_2 \ln\left(\frac{e_1^{\text{new}}}{e_1^{\text{old}}}\right)}_{\text{Effect on effort}} \tag{24}$$

where the effect on the quality-time inputs is given by the production function described in Equation 5:

$$\theta_2 \ln\left(\frac{e_1^{\text{new}}}{e_1^{\text{old}}}\right) = \theta_2 \ln\left(\frac{\gamma_0\left(\tilde{e}_1^{f,\text{new}}\right)^\phi - \gamma_1\left(\tilde{e}_1^{m,\text{new}}\right)^\phi}{\gamma_0\left(\tilde{e}_1^{f,\text{old}}\right)^\phi - \gamma_1\left(\tilde{e}_1^{m,\text{old}}\right)^\phi}\right) \tag{25}$$

and the new inputs ($a_1^{\text{new}}, \tilde{I}_1^{\text{new}}, e_1^{\text{new}}, e_1^{\text{old}}$) are the solution to the problem of the household with the new state space given by the policies introduced as described in Equation 23.

To summarize, a policy giving cash transfers to mothers affects the budget of the household and

also shifts the bargaining power, which makes households optimize and potentially chose different levels of labor supply, consumption, monetary investments, and effort. How much these changes affect the skills of children depends on the productivity of childcare, monetary investments, and effort, in terms of the skills of the child, and the degree of substitutability between paternal and maternal effort.

The other policy counterfactuals considered are cash transfers given to fathers, childcare subsidies, and price reductions in monetary investments, and childcare subsidies. These counterfactuals are implemented by modifying the state space in the following way:

$$\text{Cash transfers to fathers:} \quad Y_1^{f,\text{new}} = Y_1^{f,\text{old}} + q_1^f$$

$$\text{Childcare subsidy:} \quad P_a^{\text{new}} = P_a^{\text{old}} \times (1 - s_a)$$

$$\text{Monetary investments subsidy:} \quad P_{I,1}^{\text{new}} = P_{I,1}^{\text{old}} \times (1 - s_I) \tag{26}$$

where q_1^f is the transfer given to the father. s_a is the childcare subsidy, and s_I is the corresponding subsidy monetary investment subsidy. Note that the introduction of each policy would affect household behavior in a different way depending on the fundamentals of the model such as parental preferences for children, the determinants of the bargaining power, and the technology of skills formation. For such a reason, it is not evident at first hand which policy is more beneficial for child development. The usefulness of this model is that it allows to asses how each policy affects household behavior and how such behavior ultimately affects the process of skills formation in children. The details on how each counterfactual is introduced in the model, and the results of each policy counterfactual, are presented in Section 5.

3 The Early Childhood Longitudinal Survey of Chile

The main dataset for this paper is the Early Childhood Longitudinal Survey of Chile (ECLS). The first wave of this survey was collected in 2010 and includes a nationally representative sample of all households in Chile with a child under 5 years of age, which accounts for 15,175 households. The second wave was implemented in 2012 and included 85% of the households in the original sample and a new sample of 3,135 new households with children younger than 2 years of age, which makes the entire sample consisting of 18,310 households. In each wave, information about labor force participation for every member older than 15 was collected, together with income, educational background, knowledge about the process of early childhood development and productive routines performed with the child, such as reading books, teaching letters and taking children to the park.

I exclude from the analysis those households that were not surveyed in both waves, or those who did not complete the relevant questionnaires for the analysis such as households where children did not complete all cognitive tests. In addition, since the model analyzes households

with one child, I include only households where both parents are present and where there is only one child or if there are siblings, they are more than five years apart[17]. The description of how the sample is restricted and how I reach the final sample of analysis is described in Table 1.

Table 1: Description of sample used in the analysis

Filter	Number of households
Initial sample	18,310
Household not surveyed in 2012	16,033
Household not surveyed in 2010	12,898
Parent not living in household	7,855
Siblings within five years of age	4,125
Children's incomplete questionnaire	2,247
Family's incomplete questionnaire	950

Descriptive statistics of the sample used are reported in Table 2. Mother's and fathers are, on average, 34.5 and 37.4 years old. In terms of years of schooling, mothers attain 11.27 years on average whereas fathers get 10.72. Mothers work on average 24.22 hours a week for an average weekly wage of $165.5USD whereas the corresponding numbers for fathers are whereas fathers do so at 43.2 hours and $170.95 USD. Average income in the household is $249.1 USD a week, and we see that on average children are 64.6 years old in the second wave of the survey, in 2012.

Table 2: Descriptive statistics - Using 2012 wave of survey

Variable	Mean	25%	75%	Sd
Mother's age	34.52	29.00	39.00	6.94
Father's age	37.41	32.00	43.00	7.96
Mother's years of schooling	11.27	10.00	12.00	2.97
Father's years of schooling	10.72	8.00	12.00	3.13
Mother's hours of work (week)	24.22	0.00	45.00	21.34
Father's hours of work (week)	43.20	45.00	48.00	16.03
Mother's weekly wage (1,000 CLP)	82.73	41.86	95.24	92.78
Mother's weekly wage (USD)	165.46	83.72	190.49	185.55
Father's weekly wage (1,000 CLP)	85.48	42.62	93.02	88.19
Father's weekly wage (USD)	170.95	85.23	186.05	176.39
Household's total Income (Weekly-CLP)	124.55	59.88	151.16	108.83
Household's total Income (Weekly (USD))	249.10	119.76	302.33	217.66
Age of child (months)	64.60	58.00	72.00	8.40

The ECLS includes multiple test scores for children and questionnaires answered by the primary caregiver of the child in order to assess the skills level of children, for different domains such as socio-emotional development, behavioral problems and development of vocabulary. The description of the tests included in the sample is included in Tables 3 and 4. These test scores are used as a noisy measure of children's skills in the estimation of the model.

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[17](Bernal, 2008) and Del Boca et al. (2014) impose similar restrictions.

Table 3: 2010 Tests-Measures of child skills in period $t = 1$.

Test	Description	Ages (in months)
TEPSI	Psychomotor development test. Three areas of psychomotor development are included: coordination, language and gross motor development.	24-60
CBCL	Child Behavior Checklist. Seven dimensions for socioemotional development: Emotional intelligence, Anxiety-depression, Somatic complaints, Isolation, sleeping disorders, aggressive behaviors and attention deficit.	18-60

Table 4: 2012 Tests-Measures of child skills in period $t = 2$

Test	Description	Ages (in months)
TADI	Test of Early Childhood Learning. 4 dimensions including cognition, motor skills, language and socio-emotional development. For each one, two scores are computed: raw and total.	6-84
BATELLE	Batelle Instrument for Child Develpoment. Five dimensions of child development in addition to a total-comprehensive child development score	6-84
TVIP	Peabody Picture Vocabulary Test. A raw score as well as a standardized score is computed.	30-84

The ECLS includes a wide range of variables characterizing the investments that parents make in their children. This information is used as noisy measures of paternal and maternal effort for the estimation of the economic model -the variables $e_t^{f,*}$ and $e_t^{m,*}$ in the model. For instance, each parent reports the weekly frequency with which they read books, tell stories, sing, share meals or go to the parks with their child. The specifics os these variables are included in the Online Appendix in tables in Tables C.1 and C.2, together with their descriptive statistics[18].

The dataset also includes information about other type of investments that parents make in their children such as availability of toys, music, and food, puzzles, books for children, among others. Previous studies such as Del Boca et al. (2014) and Bernal (2008) take into account such factors in the production of skills in children but do not observe such measures of investments. The identification of how monetary investments affect the production of skills in children in their studies relies, then, on functional forms assumptions. Going beyond previous studies, this information will shed some light on how parents invest in their children and what are the

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[18]In Section F of the Online Appendix I report some descriptive statistics about these measures showing, for instance, that mothers spend more time than fathers in every activity, even after controlling for labor force participation.

main tradeoffs faced by families when making such investments. Some of these measures are exactly the same as those used in Cunha et al. (2010), which come from the HOME inventory test score. The details of the measures used to asses the level of monetary investment in the children can be found in Tables C.3 and C.4 in the Online Appendix. This information is used as noisy measure of monetary investments that parents make in their children (I_t^*) for the estimation of the economic model.

The dataset also includes information related to health at birth such as height and weight at birth, incidence of preeclampsia, depression or anxiety during pregnancy, and alcohol or drug abuse during pregnancy, among others. The information is used as noisy measure of health at birth of the child (s_0) and the specifics are described in Table C.5 of the online appendix. The ECLS also includes cognitive and non-cognitive test scores for the primary caregiver of the child. This measures are described in Table C.6 of the online appendix and will be used as noisy measures of the corresponding variable *PG* in the economic model.

A novel feature of this dataset is the inclusion of information regarding female empowerment and gender roles that I use as noisy measures of the Pareto weight of each member μ_t. These variables are reported in Table 5. We can see, for instance, that parents are asked which parent decides how to spend the income, who "should" take care of children and if they agree with statements such as "both spouses should contribute to household income" or "men should go to work and women should stay home". This constitutes a contribution to the estimation of collective model of household behavior as I use direct measures of decision-making to identify the bargaining power of each member, as opposed to consumption of private goods[19].

Table 5: Measures used for Pareto weight

A woman who is in charge of most part of tasks of the household has no time to work*
Both spouses should contribute to household income*
Men should go to work and women should stay home*
Men should participate in household chores more actively than they actually do*
If my spouse earned enough there is no reason for me to work*
After having children, the best for a woman is to develop her carreer*
Having a payed job is very important in life*
Having a payed job is the best way for a woman to become independent*
Fathers time is as important as mothers time for child development*
It is better to have a bad marriage than to remain single*
Mother decides how to spend income
Father decides how to spend income
Both, father and mother, decide how to spend income
Mothers should take care of children
Fathers should take care of chidlren
Women's only activity should be taking care of children
Women should take care of chidlren and work part time
Women should work full time and delegate childcare to a third party
Men are the best suited to take care of children
*: For each question the woman provides an answer between 1 to 5 with the following scale: Disagrees very much; disagrees; doesn't know; agrees; agrees very much.

[19]See, for example Cherchye et al. (2012).

In addition to the ECLS, I use information about the location of every preschool provider in Chile and I compute the distance from each center to each household[20]. I use the relative availability of preschool providers near each household as a shifter in the cost of childcare and monetary investments in children as indicated in Equation 14. Finally, I use information from the household survey (CASEN) in 2011, together with the CENSUS dataset in order to obtain some of the distribution factors introduced in Equation 8. The descriptive statistics of the distribution factors can be found in Table 6.

Table 6: Summary statistics-Variables determining Pareto weight[*]

Variable	Mean	(Std. Dev.)
Father's non-labor income share	0.28	(0.35)
Age difference (Father-Mother)	2.89	(5.19)
Difference in grades attained (Father-Mother)	-0.55	(2.84)
Sex ratio in region (Women/Men)	1.02	(0.06)
Unemployment ratio in region (Men/Women)	0.67	(0.11)
Wage ratio in region (Men/Women)	1.41	(0.07)

[*] The ratio of wages offered is not reported in these table as is the results of the parameters estimated in the model.

4   Estimation

A challenge in the estimation of this model is that we do not directly observe the main elements of the model in the dataset. That is, we do not observe perfectly monetary investments (I_t), parental effort in their children ($e_t^{f,*}, e_t^{m,*}$), bargaining power μ_t or skills of the children and the primary caregiver (s_t, PG). However, we observe noisy measures for each of these variables. As described in the previous section, information about the different routines that parents perform with their children, such as how often they read to their children, or how frequently they share meals, can be used to say something about e_t^j for $j = m, f$. I use the measures described in the Online Appendix C to identify the distribution of these latent factors. Consider K as the set of log-latent variables in the model[21] which we only observe indirectly via noisy measures:

$$K = \{\{\ln(s_t), \ln(e_t^{f,*}), \ln(e_t^{m,*}), \ln(I_t^*), \mu_t\}_{t=1,2}, \ln(PG), \ln(s_0)\} \tag{27}$$

And as is common in the literature[22] I assume a linear relationship between the measures and the latent factors $k \in K$ is given by the following linear system:

$$Z_m^k = \iota_{m,0}^k + \iota_{m,1}^k k + \varepsilon_m^k \text{ for } m = 1...N_k \tag{28}$$

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[20]Section G of the Online Appendixprovides a detailed description of this dataset

[21]All variables are used in logs except for the bargaining power μ_t.

[22]Assuming a linear relationship simplifies the analysis but is not necessary for identification, as shown in Schennach (2004)

where Z_m^k denotes the measure m for the latent variable $k \in K$ and N_k denotes the number of measures available for the latent factor $k.\varepsilon_m^k$ is the corresponding measurement error.

The measures used for bargaining power skills of children in period $t = 1,2$ are described in Tables 3 and 4. The measures used for the bargaining power μ_t are described in Table 5. The measures for the rest of the latent factors are described in the Online Appendix in Tables C.1 to C.6.

Given the structure of the model, there is a well-defined likelihood function denoted by $\mathscr{L}(\Theta|O;X)$ where (O) denotes the observed outcomes in the three periods: $O = \{O_0, O_1, O_2\}$, X is the set of exogenous characteristics in the model and Θ the set of parameters. The set of outcomes for the period 0 are composed exclusively of the measures of the primary caregiver's skills and birth outcomes. The set of observed outcomes for the first and second period are the measures corresponding to the specified factors in addition to the labor supply decision and the observed wages. Formally:

$$O_0 = \{\{Z_m^{\ln(PG)}\}_{m=1}^{N_{\ln(PG)}}, \{Z_m^{\ln(s_0)}\}_{m=1}^{N_{\ln(s_0)}}\}$$

That is, the observed outcomes in period 0 correspond exclusively to the measures used for health at birth s_0 and the measures used for skills of the primary caregiver PG. For t=1 the set of observed outcomes is given by:

$$O_1 = \{h_1^f, h_1^m, a_1, \mathscr{Z}_1\} \cup \underbrace{\{w_1^f\}}_{\text{if } h_1^f > 0} \cup \underbrace{\{w_1^m\}}_{\text{if } h_1^m > 0}$$

that is, the decision of labor supply for each member (h_1^f, h_1^m), wages (w_1^f, w_1^m) for those who participate in the labor market, preschool/daycare decisions a_1 and the set of observed measures $\mathscr{Z}_1$ which consists of all measures used for the latent factors in the first period:

$$\mathscr{Z}_1 = \{\{z_m^{\ln(s_1)}\}_{m=1}^{N_{\ln(s_1)}}, \{z_m^{\ln(e_1^{f,*})}\}_{m=1}^{N_{\ln(e_1^{f,*})}}, \{z_m^{\ln(e_1^{m,*})}\}_{m=1}^{N_{\ln(e_1^{m,*})}}, \{z_m^{\ln(I_1^*)}\}_{m=1}^{N_{\ln(I_1^*)}}\} \tag{29}$$

where N_k corresponds to the number of measures used for factor k. For instance, in Table C.1 I report 14 measures of parental effort $(e_t^{*,j})$ which implies that $N_{\ln(e_t^{*,j})}=14$. The set of observed outcomes for the second period does not include the childcare decisions but includes the measures used for the Pareto weight, which are described in Table 5 and are only included in the second period.

$$O_2 = \{h_2^f, h_2^m, \mathscr{Z}_2\} \cup \underbrace{\{w_2^f\}}_{\text{if } h_2^f > 0} \cup \underbrace{\{w_2^m\}}_{\text{if } h_2^m > 0}$$

$$\mathscr{Z}_2 = \{\{z_m^{\ln(s_2)}\}_{m=1}^{N_{\ln(s_2)}}, \{z_m^{\ln(e_2^{f,*})}\}_{m=1}^{N_{\ln(e_2^{f,*})}}, \{z_m^{\ln(e_2^{m,*})}\}_{m=1}^{N_{\ln(e_2^{m,*})}}, \{z_m^{\ln(I_2^*)}\}_{m=1}^{N_{\ln(I_2^*)}}, \{z_m^{\mu_2}\}_{m=1}^{N_{\mu_2}}\} \tag{30}$$

To obtain the likelihood function in terms of the elements of the model, and the measurement system, it is necessary to integrate over the distribution of latent factors in K. That is, we do not observe with precision each element $k \in K$, for this reason, we integrate over its distribution. The derivation of the full likelihood is included in the Section A.1 of the Appendix. In the remaining of this section I describe the

assumptions regarding the distributions that emerge in the likelihood function.

I assume that the error term in the measurement system follows a normal distribution centered around zero and that they are independent across measures:

$$\varepsilon_m^k \sim N(0, \sigma_{k_m}^2) \text{ for } m = 1...N_k, \forall k \in K \tag{31}$$

I assume that PG follows a normal distribution and that the skills at birth follow a normal distribution where the mean depends on the skills of the primary caregiver. This allows for the possibility of a correlation between parental and children's skills:

$$\ln(s_0)|\ln(PG) \sim N\left(\delta_{s_0} \ln(PG), \left(\sigma_{\ln(s_0)}\right)^2\right) \tag{32}$$

$$\ln(PG) \sim N\left(0, \ln\left((\sigma_{\ln(PG)})^2\right)\right) \tag{33}$$

As described in the economic model, I allow for heterogeneity in the productivity of parental effort, monetary investments $X_t^* = \left(e_t^{*,f}, e_t^{*,m}, I_t^{*,m}\right)$. That is, when parents invest x_t, the real investment becomes $x_t^* = x_t \exp\left(\eta_x^t\right)$ for $x_t^* \in X_t^*$. I assume that this heterogeneity term follows a normal distribution centered around zero.

$$\eta_k \sim \mathcal{N}\left(0, \sigma_k^2\right), \text{ for } k = e_t^{*f}, e_t^{*,m}, I_t^{*,m} \tag{34}$$

Now, the density of skills in period t is given by the distribution of the heterogeneity term η_{s_t} together with the production function specified in 3. I assume that the heterogeneity term follows a normal distribution as well centered around zero:

$$\eta_{s,t} \sim \mathcal{N}\left(0, \sigma_s^2\right) \tag{35}$$

Finally, the density of the Pareto weight is given by the distribution of v_t combined with the parametrization specified in Equation 7. Finally, I assume that the heterogeneity term in the Pareto weight, v_t, follows a normal distribution conditional on the skills of the primary caregiver:

$$v_t \sim \mathcal{N}\left(\delta_\mu \ln(PG), \sigma_\mu^2\right) \tag{36}$$

The gaussian and independence assumptions made about the measurement system and the heterogeneity terms are not necessary for purposes of identification, as will be shown in Section 4.1. Such assumptions should be considered as simplifying rather than for identifying ones.

I assume a Mincer-type equation with Gaussian error term for the wages:

$$\ln(w_t^j) = \beta_0 + \beta_1 yrschool^j + \beta_2 age_t^j + \beta_3 \left(age_t^j\right)^2 + \varepsilon_{w_t^j} \tag{37}$$

$$\varepsilon_{w_t^j} \sim \mathcal{N}\left(0, \sigma_{w^j}^2\right)$$

Lastly, the preference shocks ε_t enter into the likelihood function. I assume a Gaussian distribution as well, centered around zero. Such preference shocks enter through their CDF as the probability of observing the actions of labor supply and childcare decisions, as being the optimal ones for each household.

The likelihood includes a high-dimensional integral with no closed form solution. The natural approach to estimate such likelihood is to approximate the integral via Monte-Carlo methods. However, skills in a given period depend on skills in previous period and this dynamic generate an additional difficulty: for each draw in period 0, we would have to generate multiple draws in the first period and for each draw in the first period we would have to draw multiple draws in the second period. Because of this curse of dimensionality, a pure simulation strategy would be computationally unfeasible.

I adapt a particle filter algorithm to estimate the model via simulated methods (Creal, 2012). The full description of the estimation technique and the derivation of the likelihood function are described in Appendix A.2. Other approaches such as the Kalman filter (Cunha & Heckman, 2008) or the unscented and extended Kalman filter have been proposed previously in the literature (Cunha et al., 2010). However, this would imply an approximation of the dynamics of the model that would possibly limit the non-linearities arising in the system (Fernández-Villaverde & Rubio-Ramírez, 2007). To the best of my knowledge, this is the first application of a particle filter algorithm in the estimation of a microeconomic model.

4.1   Identification

The identification argument is divided into two parts. First, I show how the parameters of the measurement system and the distribution of skills, which leads to the production function of skills, are identified. Secondly, I show identification of the parameters related to the economic model related to the preferences of the household.

4.1.1   Measurement System and Distribution of Skills

We can write the measurement system specified in Equation 28 in matrix form:

$$Z = \iota_0 + \iota_1 K + \varepsilon$$

where $Z \in \mathbb{R}^M$ contains all the measures available, M is the total number of measurements for all the factors, $K \in \mathbb{R}^{11}$ is the vector of 11 factors and $\varepsilon \in \mathbb{R}^M$ is measurement error. $\iota_1 \in \mathbb{R}^{M \times 11}$ is the matrix of factor loadings. It is necessary to identify the elements in ι_0, ι_1, and the variance-covariance matrix of ε given that we only observe Z. As is common in factor analysis, a location and scale normalizations are necessary to ensure identification of the system. The first step is to normalize the first element of ι_1 for each measure to one, which corresponds to setting $\iota_{1,1}^k = 1$ for every factor $k \in K$ in Equation 28. The location normalization corresponds to setting the mean of each factor to a specified level. The scale is set to be:

$$\mathbb{E}[\ln(s_0)] = \mathbb{E}[\ln(PG)] = 0 \qquad \mathbb{E}[\mu] = 0.5$$

$$\mathbb{E}\left[e_t^{f,*} \mid \mu = 0.5, h^f = 1\right] = 1 \qquad \mathbb{E}[I_t^* \mid \mu = 0.5] = 1$$

That is, log-skills at birth $(\ln(s_0))$ and log-skills of primary caregiver $(\ln(PG))$ are normalized so that the population average is zero[23]. The Pareto weight is normalized to have mean 0.5. Effort is normalized so that the average level for a father participating in the labor market, in a family with Pareto weight equal to 0.5, is 1. Maternal effort is not normalized as it is interpreted in terms of paternal effort. Investments are normalized so that the average for a family with a Pareto weight of 0.5 is equal to 1.

I assume that measurement errors of skills at birth are independent with error terms of other factors. Formally, the assumption is given by $\varepsilon_m^{\ln(s_0)} \perp\!\!\!\perp \varepsilon_{m'}^{k'}$ for $m = 1...N_{\ln(s_0)}$, $k \neq \ln(s_0)$, $m' = 1...N_k$.

I can recover ι_m^k by noting that:

$$\frac{Cov(Z_m^k, Z_1^{\ln(s_0)})}{Cov(Z_1^k, Z_1^{\ln(s_0)})} = \iota_{m,1}^k$$

As shown in Schennach (2004), to identify the probability density function of the factors K, it must be the case that each factor $k \in K$ has at least two measures $j = 1, 2$ such that $\mathbb{E}\left[\varepsilon_j^k | K, \varepsilon_{j'}^k\right] = 0$ and $\varepsilon_{j'}^k \perp\!\!\!\perp K$. It is thus necessary to assume that there are at least two measures for each factor to identify -non-parametrically- the probability density of the factors.

By identifying the probability density of the factors $f(K)$, we can obtain the density of skills in $t + 1$ conditional on all other factors in period $t + 1$ and on skills in period t. The log of the production function of skills in Equation 3 is this density with the heterogeneity term η_s. The additively separable assumption is enough to non-parametrically identify this function (Matzkin, 2007) .

4.1.2 Economic model

The parameters of the economic model are identified by a combination of exclusion restrictions, exogenous sources of variations and functional form specifications. The main argument used to identify preferences of fathers and mothers follows standard procedures from the literature on collective models of household behavior (Chiappori & Donni, 2009). The use of distribution factors -variables that affect the behavior of the household but do not modify household behavior in any other way- allows me to identify preferences of mothers and fathers. The intuition of the identification argument is that variation in the distribution factors will change the behavior of the household through the bargaining power. This allows us to separately identify preferences of fathers and mothers. The distribution factors used in this article have been previously used in the literature (Cherchye et al., 2012; Attanasio & Lechene, 2014; Blundell et al., 2005).

First, I describe identification of the Pareto weight function specified in Equation 7 because, through this function, we can separately identify preferences of fathers and mothers. To identify parameters in Λ, I use exogenous variation in the gender wage gap, the unemployment gender gap and the sex ratio. The key assumption is that we have enough variation in the data for these factors, and variation is given in a way that is exogenous to the household.

In addition to variation in the distribution factors, the way in which the Chilean social security system schedules monetary transfers to households generates variation in the proportion of income earned by men in the household. The "Social Protection Card"[24] assigns a score to each household corresponding

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[23] As found in Agostinelli and Wiswall (2016), skills only need to be normalized in period 0.

[24] "Ficha de Proteccion social" in Spanish

to its socioeconomic status. This score is used as the main targeting device through which monetary transfers are assigned to households, and all subsidies are given to mothers of children whenever there is a child in the household. The amount of the subsidy depends on an additional set of characteristics of the households, such as the number of children under 18 living in the household. There are seven different programs giving monetary transfers to families in Chile, but the basic ones correspond to the "Unique Family Subsidies" and "Family Assignments". Under these programs, a mother who earns less than $187,515 CLP and has a score under 11.734 on the Social Protection Card, is eligible to receive a transfer of $7,179 CLP per month, for each child under 18 and for herself. Additionally, families with a lower score on the Social Protection Card are eligible for subsidies, all received by the mother, depending on their score, the months they have currently been beneficiaries of the programs and the demographic composition of the household. The structure of the basic monetary transfers in Chile is described in Figure 1. A description of how the monetary subsidies scheduling system has evolved over time is available in section H of the online appendix.

Figure 1: Monetary Transfers to Families in Chile[*]
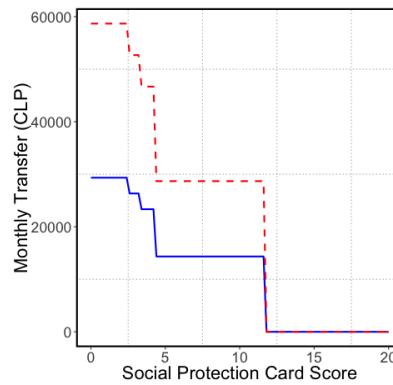
[*]This figure shows how monetary transfers to families are scheduled to families according to their score in the Social Protection Card. The total value of the transfer for each family corresponds to three different programs: "Unique Family Subsidies", "Family Assignments and "Social Protection Transfer". The conditions to be eligible for these programs are to have a score in the Social Protection Card below 11.734 and for those who work, having a monthly income of less than $187,515 CLP. The final amount being transferred to the household also depends on the size of the household and the time they have been beneficiaries of such programs. The solid line represents the schedule for a bi-parental household with one child that has been in the program for 50 months. The dashed line corresponds to a bi-parental household with three children under 18 that has been in the program for less than six months.

The discontinuities in the monetary transfer programs, as well as the variation in elements such as the number of members in the household, generates variation in the proportion of non-labor income in the hands of women. Finally, by assessing the extent to which responses in female empowerment and gender roles questionnaires changes are related to changes in the proportion of income earned by women and the distribution factors, we are able to identify the parameters in Equation 7.

Changes in effort levels for both, fathers and mothers, that are related to changes in distribution factors, allow me to recover preferences for children of both parents. For instance, variation in distribution factors might increase the bargaining power of the mother. If we see that effort levels increase as a consequence of the variation in the distribution factors, this gives us information about the relative preferences for children between fathers and mothers. Similarly, changes in investments due to changes in distribution factors allow me to identify the preferences for consumption of mothers and fathers.

Identification of the remaining parameters follows standard arguments in the literature. For wages, as long as we have enough variation in education and age, we can identify the β coefficients. Similarly, the price elasticity of investments, with respect to the availability of preschool providers $P_{I,1}$, is identified as long as we have variation in the number of preschool providers within five kilometers of households. In Figure G.1, I show that there is significant variation in the data regarding this variable. The fact that Chile saw a massive expansion in the number of providers between 2006-2010 gives us significant variation in the data, as the system increased its capacity, measured in the number of children that the system can provide services for, by 450%. The variation in childcare providers permits identification of the parameters $P_{I,1}, P_{I,0}$ in 14. Similar arguments are used to identify price of childcare [25].

5   Estimation Results

The results of the parameters estimated, together with the corresponding standard errors, are presented in Tables 7 - 15. We can see that childcare services liberate more time resources for mothers than for fathers. In the same regard, having one additional member in the household decreases the cost of time investments more for mothers than for fathers. We observe that mothers have stronger preferences for children than for consumption, when compared with fathers, and that fathers find it costlier to spend time with their child than mothers do. Having an additional person in the household helping with childcare or with household chores decreases the utility penalty of investing time in children, more for mothers than for fathers.

Regarding the estimates of the production of skills, we see some evidence of differences in the productivity of time investments of mothers and fathers. It is not possible to make comparisons between the productivities of different inputs because they are measured in different units (except father's and mother's effort). Nonetheless, we see that monetary investments, childcare attendance, skills of primary caretaker and having adequate birth conditions all seem to have positive effects on the skills of a child. We also observe that availability of childcare services decreases both the price of childcare and the price of monetary investments in children. This coefficients are estimated with high precision.

Looking at the estimates of the determinants of the Pareto weight, we see there is a significant effect of the gender-wage ratio. This is important because the relationship holds even when we control for differences in education, age and in non-labor income. We observe that, as the age gap between the man and woman decreases, the bargaining power of the man decreases as well. Interestingly, we find a negative relationship between gender ratio, unemployment ratio and wage ratio at the province level and the man's bargaining power.

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[25] An additional test to asses if parameters are well identified in the model is to observe that the likelihood function is not flat on the parameter estimates. I have performed these tests to confirm that there is some curvature around the likelihood function. Although I do not report them due to the number of parameters included, the results are available upon request.

Table 7: Estimates: Utility function. Mother's preferences

Parameter	Estimate	Standard Error
$\alpha_{1,12}^m$	0.6312	0.0028
$\alpha_{2,12}^m$	0.0517	0.0001
$\alpha_{3,12}^m$	0.3035	0.2208
$\alpha_{4,0,12}^m$	0.0136	0.0001
$\alpha_{4,1,12}^m$	0.0012	0.0001
$\alpha_{1,10}^m$	0.0554	0.0003
$\alpha_{2,10}^m$	0.0038	0.0001
$\alpha_{3,10}^m$	0.1026	0.2437
$\alpha_{4,0,10}^m$	0.0001	0.0001
$\alpha_{4,1,10}^m$	0.0001	0.0001
$\alpha_{5,10}^m$	0.8381	0.3831

Table 8: Estimates: Utility function. Father's preferences

Parameter	Estimate	Standard Error
$\alpha_{1,12}^f$	0.1587	0.0026
$\alpha_{2,12}^f$	0.0339	0.0001
$\alpha_{3,12}^f$	0.8042	0.3610
$\alpha_{4,0,12}^f$	0.0032	0.0001
$\alpha_{4,1,12}^f$	0.0016	0.0001
$\alpha_{1,10}^f$	0.6157	0.0026
$\alpha_{2,10}^f$	0.1407	0.0005
$\alpha_{3,10}^f$	0.8042	0.4496
$\alpha_{4,0,10}^f$	0.0114	0.0001
$\alpha_{4,1,10}^f$	0.0001	0.0001
$\alpha_{5,10}^f$	0.0057	1.0415

Table 9: Estimates: Preference shock

Parameter	Estimate	Standard Error
$\sigma_{W,A}^m$	3.663	0.835
$\sigma_{NW,A}^m$	0.909	0.114
$\sigma_{NW,NA}^m$	0.079	0.247
$\sigma_{W,A}^f$	0.502	0.452
$\sigma_{NW,A}^f$	0.085	0.455
$\sigma_{NW,NA}^f$	0.002	0.078

*Preference shocks for work-no childcare are standardized to zero

Table 10: Estimates: Mothers wages

Parameter	Estimate	Standard Error
β_0^m	5.7874	0.4394
β_1^m	0.2757	0.0251
β_2^m	0.0732	0.0379
β_3^m	-0.0006	0.0006
σ_{w_m}	0.8280	0.0606

Table 11: Estimates: Fathers wages

Parameter	Estimate	Standard Error
β_0^f	5.8103	0.2997
β_1^f	0.1260	0.0055
β_2^f	0.1875	0.0156
β_3^f	-0.0022	0.0002
σ_{w_f}	0.6894	0.0130

Table 12: Estimates: Production of Skills

Parameter	Estimate	Standard Error
θ_0	0.2128	0.0011
θ_1	0.2673	0.0017
θ_2	0.5199	0.0032
ϕ	0.4688	0.0007
γ_f	0.3647	0.0006
γ_m	0.6353	0.0016
δ_0	-0.8000	0.0051
δ_1	-0.0000	0.0001
δ_2	0.0010	0.0004
$\delta_{3,10}$	3.5038	0.0172
$\delta_{3,12}$	5.3000	0.0408
δ_4	0.0130	0.0001
σ_s	1.5754	0.0065

Table 13: Estimates: Distribution of latent factors

Parameter	Estimate	Standard Error
σ_{ef}^m	2.5133	0.0039
σ_{ef}^f	3.3754	0.0025
σ_{inv}	2.1896	0.0144

Table 14: Estimates: Prices

| Parameter	Estimate	Standard Error
Price_{I_0}	966.2378	1.8225
Price_{I_1}	1.0537	0.0019
Pchildcare_0	2440.6020	1.1684
Pchildcare_1	622.6098	1.2417

Table 15: Estimates: Pareto weight

Parameter	Estimate	Standard Error
λ_0	-2.7321	0.0136
λ_1	0.0023	0.0143
λ_2	0.0527	0.0006
λ_3	-0.1194	0.0001
λ_4	0.0036	0.0026
λ_5	-2.5325	0.0039
λ_6	-0.0069	0.0328
λ_7	-0.7722	0.0006
σ_μ	0.5179	0.0074

In Figures I.1, and I.2 of the online appendix, I show the distribution of test scores according to the distribution of income in the sample. We do observe a significant gradient between socioeconomic status and cognitive achievement in five year old children. Additionally, we can combine test scores and estimates of the production function to obtain more precise estimates about the distribution of the skills in the estimation sample, the smoothing distribution. The smoothing distribution is an estimate of the probability density function of skills for each child using both, test scores and estimates of the production function, it is reported in Figure 2. We see a positive correlation between family s wealth and children's skills [26].

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[26] In Section J of the appendix I include the description of how the smoothing distribution is constructed.

Figure 2: Distribution of skills by Income
Smoothing distribution
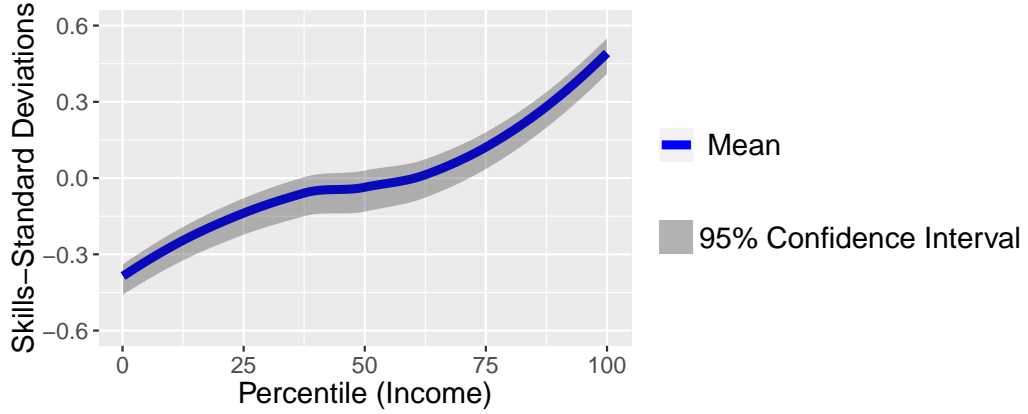
A by-product of the estimation results is the signal to noise ratio for each measure. That is, I am able to assess the proportion of the variance in a given measure that is due to measurement error or to true signal related to the underlying factor:

$$\text{Signal-noise ratio}_{m,k} = \frac{\iota_{m,1}^2 Var(k)}{\iota_{m,1}^2 Var(k) + Var(\varepsilon_m^k)} \tag{38}$$

The signal to noise ratio of each measure is presented in the online appendix in Section K. This is particularly useful for test scores as we are able to asses which tests measure more accurately skills for children. For instance, as shown in Table K.9, the Batelle-Cognitive test score is a less noisy measure of skills for children than the Tadi-Language test.

5.1   Model fit

The model does a good job when predicting labor force participation and childcare decisions of the household. In Figure 3 I report the labor force participation of women in the 2010 and 2012 wave according to their education. In both waves, we see an increasing pattern in both, the data and the predicted pattern from the model. Figure 4 shows that the model also does a good job predicting male's labor force participation in both waves. The predicted and observed distribution of wages for both surveys is reported in Figure 5, where we observe that the model is able to replicate the main features of its distribution.
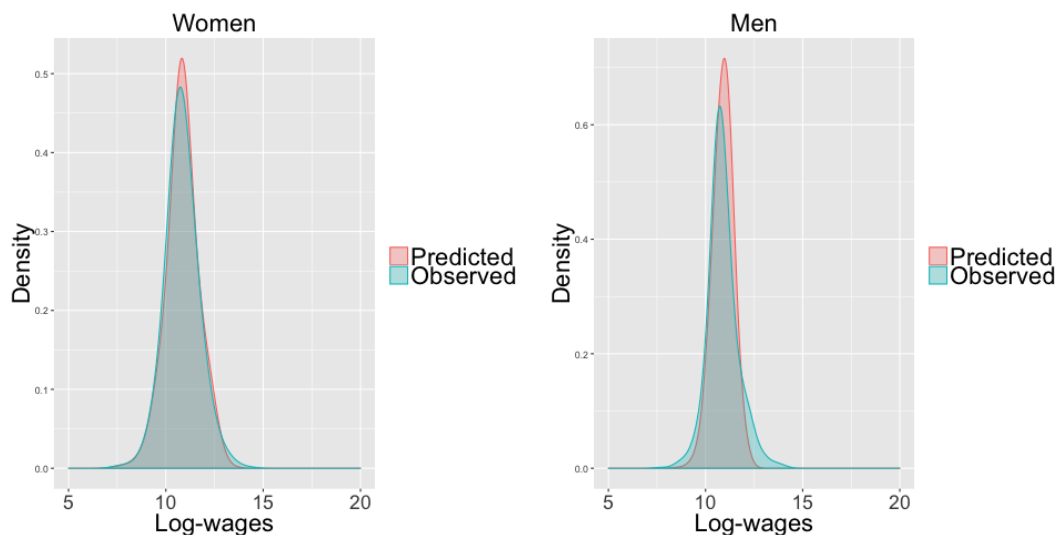
Figure 3: Model fit: Female labor force participation according to education

Figure 4: Model fit: Male labor force participation according to education

Figure 5: Model fit: distribution of wages

Kernel density estimates of predicted and observed wages.

Bandwidth chosen is 3.

Regarding demand for preschool/daycare services, Table 16 shows that in the data, 67.7% of children whose mother works attend to childcare services whereas for non-working mothers is 42.9%. The corresponding figures for the predicted model are 68.4% and 42.9%[27].

Table 16: Model Fit - Demand for childcare

Childcare Attendance	Predicted	Data
Working Mothers	68.4%	67.7%
Not-working Mothers	41.6%	42.9%

5.2 Evaluating the Effects of Government Programs on the Skills of Young Children

In this section I simulate the effects of four different policies on the skills of children. In every case, the policy beneficiaries are the poorest 20% households. The policies are: cash transfers to mothers, cash transfers to fathers, childcare subsidies, and subsidies for child investments.

5.2.1 Cash Transfers

Cash transfers are a widely-used policies for families in disadvantage. Every country in Latin America has a form of cash transfer that varies by the amount given to the households and the type of conditions that families need to fulfill in order to be beneficiaries (Fiszbein et al., 2009). Policymakers often invoke the effect of such programs on the promotion of skills of young children as one of the many benefits of

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[27]Given that some of the predicted values depend on unobserved shocks to the econometrician, the predicted version is done by setting the value of the shocks at its mean. In Section L of the Online Appendix I extend the results of the model fit showing the distribution of the fit given by the distribution of the corresponding shocks.

these policies. Moreover, the vast majority of these programs establish that, for families with children, the mother should always be the beneficiary. The main argument for this is that cash in the hands of women is associated with better child outcomes than cash in the hands of men (Doepke & Tertilt, 2014).

From 2012 to 2016, the minimum amount of Cash Transfers given to families with children, in condition of disadvantage, has increased, in real terms, by approximately 72.8% from $14,340 CLP in 2010 to $28,327 CLP in 2016[28]. Although this represents a large increase, the current transfer is equivalent to 6% of the median income. Taking into account that in countries such as Brazil or Mexico the basic transfer can represent up to 25% of the median income, this is a small transfer compared to countries in the region (Fiszbein et al., 2009).

The first counterfactual, giving the additional transfer to mothers, is implemented by setting the new budget constraints to the household setting non-labor income from the mother equal to the old non-labor income plus the additional transfer: $Y_t^{m,\text{new}} = Y_t^{m,\text{old}} + q_t^m$, as specified in Equation 26 where q_t^m corresponds to the transfer given, which is equivalent to $13,987 CLP. Note that cash transfers not only increase the budget constraint of the family but also shift the Pareto weight of each member as specified in Equation 7. The policy is simulated in the two periods so that both, in $t = 1$ and $t = 2$, maternal non-labor income increases by $13,987 CLP.

As a way to identify the extent to which targeting mothers as sole beneficiaries of cash transfers make a difference in the skill formation process of their children, the second counterfactual implemented consists of giving the same amount of money to fathers rather than mothers. Although the effect on the budget constraint is the same, such modification changes the Pareto weight towards the father. This consists on setting the non-labor income for fathers to: $Y_t^{f,\text{new}} = Y_t^{f,\text{old}} + q_t^f$ where $q_t^f = \$13,987$ for $t = 1,2$ and for households in the lowest 20% of the income distribution.

5.2.2 Childcare Subsidies

Free childcare and preschool policies have also been very popular not only as a way to promote skills in young children but also as a tool to promote female employment. In 2013, the government of Chile established free and mandatory preschool services for children older than five years of age. Partly due to this policy, Chile is now the country with the highest expenditure on preschool education as a share of total government expenditure, among countries in the OECD. [29] Due to the increasing importance of such public policies, in the third counterfactual I simulate the effects of setting subsidies for preschool services for families located in the lowest quintile of the income distribution.

Childcare subsidies are implemented in the economic model by setting the price of the childcare services equal according to $P_a^{\text{new}} = P_a^{\text{old}} \times (1 - s_a)$ where s_a is the subsidy. In the model, childcare services are only available in the first period, thus the policy is only simulated for the first period and is only given to the families in the lowest 20% of the income distribution. In order to set the same costs as cash transfers, the total expenditure from the government by setting this subsidy should be equal to the total amount spent in the first and second counterfactual scenario.

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[28]1$ USD $\approx$ 650 CLP. Inflation in Chile has been stable between 2% and 4% in that period. The details of how the cash transfer program operates and the description of how the amount of cash transfers have increased are included in Section H of the Online Appendix.

[29]Out of the total government expenditures, 2.3% go to the preschool system compared to the average of other OECD countries, which is 1.1% (Chile, 2013).

5.2.3 Subsidies to Monetary Investments

Finally, in the fourth counterfactual I simulate the effects of subsidizing monetary investments for children. Although probably less prevalent than childcare subsidies or cash transfers, programs aimed directly at increasing non-time investments in children from parents have been starting to be implemented in developing and developed countries. In Chile, for example, such transfers are being done through the "Chile Crece Contigo"[30] (ChCC) program, established in 2009. ChCC is composed of a set of services for poor families with children younger than five years of age. The goal of the program is to guarantee that every child has the necessary resources so that they can achieve their full developmental potential during childhood. The program offers resources to parents such as a 24-hour phone line for inquiries about child development, and the distribution of books, toys, songs and story books for children, as well as providing learning materials to parents in order to increase their knowledge about child development. ChCC is the most important child development public program currently operating in Chile.

The program of subsidies to monetary investments for families is implemented in the economic model by setting the new price of investments according to: $P_{I,t}^{\text{new}} = P_{I,t}^{\text{old}} \times (1 - s_I)$ with s_i being the corresponding subsidy. As in the case of childcare subsidies, in order to set the same cost for this policy intervention, the amount spent by the government subsidizing monetary investments should be equal to the case of the three aforementioned counterfactual scenarios. The price is subsidized in both periods, $t = 1, 2$ and to make this policy comparable with cash transfers and childcare subsidies, the subsidy is set at a point such that the total expenditure of the government on this policy is equal to the expenditure corresponding to the other two policy counterfactuals. Finally, note that I could alternatively implement a policy of in-kind transfers to families where families would receive directly goods for child investments. However, such policy would potentially have higher implementation costs, as opposed to one subsidizing price of child investments. Moreover, to perform policy counterfactuals regarding such a policy it would be necessary to make some assumptions about the monetary costs of implementing such a policy. It is not clear at first hand how to make such assumption.

5.2.4 Results of Policy Interventions

The effects of the policy counterfactuals on employment are reported in Table 17. Cash transfers have a very limited effect on employment, a result that is consistent with the literature (Fiszbein et al., 2009). Childcare subsidies increase labor force participation but mostly for women. Such effect is consistent with the fact the high male labor force participation and low female labor force participation, together with the fact that women argue that the main reason they are not working is because of child care chores. The four policies have very limited effect on male employment.

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[30]Chile Grows with You, in Spanish

Table 17: Effects of Policy Counterfactuals on Employment

	Female labor force participation (%)	Male labor force participation (%)
Cash transfer to mother	-2.37	-1.05
Cash transfer to father	-2.37	-1.05
Childcare subsidy	3.16	-2.11
Child-investments subsidy	0.00	0.00

Effects on policy beneficiaries.
The effects correspond to averages between the first and the second period.

The effects of policy counterfactuals on children's skills is reported in Table 18. We observe that both, maternal and paternal time investments increase in response to cash transfers. As labor force participation decreases, and it is less costly to exert time effort in children for non-working parents, it is not a surprise that we observe such effect. Additionally, paternal effort increases in a higher magnitude in response to cash to women than to cash of men. This is given by the fact that cash transfers empower women and thus their preferences are weighted more. As parental effort is a privately exerted effort with public benefits, it comes as no surprise that paternal effort increases more when women are relatively more empowered, that is, when they are the beneficiaries of cash transfers.

Table 18: Effects of Policy Counterfactuals on Children's Skills

	Maternal effort[*]	Paternal effort[*]	Child investments (CLP)[*]	Skills of children[+]
Cash transfer to mother	4.71	7.07	139.41	0.40
Cash transfer to father	4.71	2.08	139.21	0.40
Childcare subsidy	-1.05	8.68	155.71	0.05
Child-investments subsidy	0.00	0.00	3252.93	3.00

Effects on policy beneficiaries.
Change in percentage points of standard deviations between baseline situation and policy change.
[*]Average effect between 2010 and 2012. For childcare subsidies, effect considered is in 2010. + Total effect in 2012.

Out of the additional weekly $3,252 CLP that families receive, only $139 are spent in child investments and it does not make much of a difference if it is the mother or the father the recipient. The total effect of cash transfers is very limited, as we only see an increase of 0.4% of a standard deviation on the skills of children in disadvantage. This is consistent with the literature suggesting that cash transfers have limited effects on skills of children (J. Heckman & Mosso, 2014; Del Boca, Flinn, & Wiswall, 2016). Cases where cash transfers have been found to have a positive and significant effect on children's skills are often because of improvement in nutritional outcomes such as a decrease in the incidence of wasting and-or stunting (Paxson & Schady, 2010; Macours, Schady, & Vakis, 2012). Such a mechanism is unlikely to operate in Chile, where the incidence of stunting and wasting in children is below 1%.

As cash transfers have a negative effect on female labor force participation, this in turns increases the amount of time that mothers spend with their children. Due the complementarity of time investments, the productivity of paternal time investments increases and thus we observe an increase in both, paternal and maternal time investments as a consequence of cash transfers. The additional expenditure on child investments, as well as the increase in time investments from both parents, is what ultimately drives the increase in 0.4% of a standard deviation in skills for children.

Childcare subsidies have a total effect of increasing 0.05% of a standard deviation skills of children in beneficiary households. Childcare attendance by itself has a very limited effect when it comes to in-

creasing skills of children, as can be seen from the point estimate of δ_2 in Table 12. However, childcare subsidies also affect the incentives faced by parents when it comes to monetary and time investments. The total change in employment depends on two effects. On the one hand, childcare subsidies make labor force participation less costly. On the other hand, they relax the budget constraint, further decreasing incentives for parents to participate in the labor market. As can be seen in Table 17, the effect on maternal employment is positive whereas that on paternal employment is slightly negative. This further translates in time investments that parents make in their children. Ultimately, childcare subsidies increase skills of children of beneficiary households in less than 1% of a standard deviation.

In Latin America, there is mixed evidence on childcare attendance and general child outcomes. Bernal et al. (2009) finds a negative effect of attendance to informal childcare services on health outcomes, but positive effects on learning outcomes for children whose exposure is more than 15 months, in Colombia. Rosero Moncayo et al. (2011) find that a negative effect of childcare on cognitive and language development in Ecuador. In Bolivia, (Behrman et al., 2004) find a positive effect of childcare attendance on children outcomes for those who attend more than seven months. It comes thus, as no surprise, that childcare attendance by itself has limited effects child's skills.

Using the same amount of money, $3,252 CLP a week, to subsidize child investments, is the most effective policy to improve skills of children in disadvantage. We observe that the average treatment effect of such a policy is an increase in 3% of a standard deviation on skills. Note that this effect is exclusively driven by the increase in investments for children as the policy does not affect labor force participation.

In order to explore how general is the fact that subsidies to child investments are more productive than the other three alternatives, I simulate the effects of these policies for multiple levels of expenditure. Figure 6 reports the results of these policy counterfactuals, for different levels of expenditure, on children's skills. Childcare subsidies can only be implemented up to the point where all children attend childcare services. Beyond that point, price of childcare becomes negative and such a policy becomes similar to cash transfers. Regarding cash transfers, we observe that having the mothers as beneficiaries is slightly better than giving them to fathers, when it comes to children's skills. As can be seen, for every given level of expenditure, subsidies to child investments are more productive than the other three alternatives.

Figure 6: Policy Effects on Children's Skills
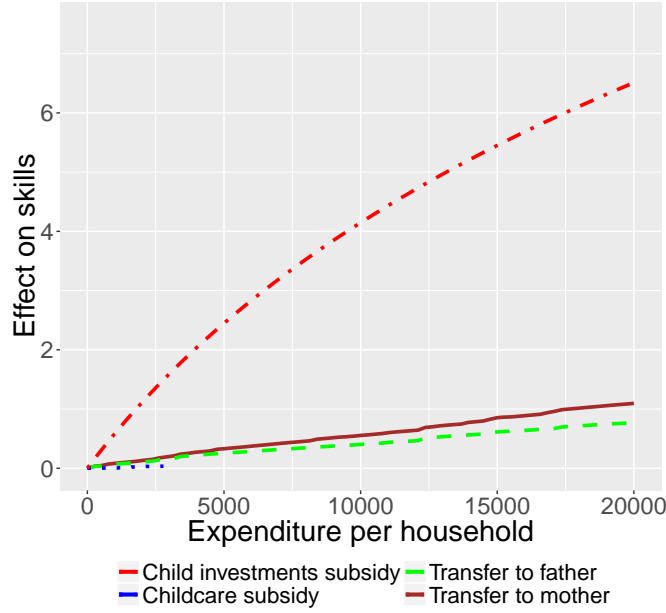
The figure shows the effect of various policy counterfactuals on the skills of children located in the lowest quintile of the income distribution. The effect is measured as percentage points of a standard deviations from the mean that the average level of skills for children in the lowest quintile of the income distribution is shifted.

6 Conclusions

Skills developed during childhood affect adult life outcomes. This fact has motivated governments to implement policies aimed at increasing skills for children in disadvantage. However, there is still uncertainty about what are the most effective ways to increase skills in young children. This article contributes to the literature by comparing three policies and their effectiveness when it comes to promote skills for children in disadvantage.

To accomplish such a goal, I develop and estimate a technology of skill formation nested within a collective model of household behavior. The model allows parents to have different preferences in order to assess the extent to which targeting individual members have consequences in the process of child skill formation. By using a rich dataset on early childhood development, I am able to estimate the skill production technology via a dynamic-latent-factor structure a-là Cunha et al. (2010), which allows me to non-parametrically identify the fundamental parameters of the production function. The non-linearities in the skill production function imposes a challenge in the estimation strategy since traditional methods for factor models, such as the Kalman filter, fail in such a setting. In this paper, I implement a particle filtering technique in order to allow for the non-linearities in the skills production.

The results of this paper show that cash transfers have a very limited effect on reducing the gaps in skills between rich and poor children. Moreover, giving the transfers to fathers or mothers does not seem to make a significant difference. Consistent with most of the literature, I find that cash transfers have a very limited effect on female labor force participation. Childcare services have a positive but modest effect on skill promotion in children, as well as on female labor force participation. The main result suggests that

the most effective way to close the gaps in skills between rich and poor children is by subsidizing goods that are specific to raising the skills of children such as books, toys, puzzles and music.

A Appendix

A.1 Derivation of likelihood function

In this section I describe in detail how the likelihood function is constructed. The expressions will be left in terms of elements defined in Section 4. The likelihood function in Equation **??** can be expressed in terms of the densities of outcomes in each period where I use $f()$ to denote a generic function:

$$\mathscr{L}(\Theta|O;X) = f(O|\Theta;X) = \underbrace{f(O_0|\Theta;X)}_{\text{Likelihood in period 0}} \times \underbrace{f(O_1|O_0,\Theta;X)}_{\text{Likelihood in period 1}} \times \underbrace{f(O_2|O_1,\Theta;X)}_{\text{Likelihood in period 2}} \tag{39}$$

The likelihood in the first period is obtained by integrating over the distribution of the relevant factors for this period: $K_0 = \{s_0, PG\}$:

$$\int_{D_0} f_0(O_0, K_0|X;\Theta)\, dK_0 = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f\left(\{\{Z_m^{\ln(PG)}\}_{m=1}^{N_{\ln(PG)}}, \{Z_m^{\ln(s_0)}\}_{m=1}^{N_{s_0}}\}\,|\,\ln(s_0), \ln(PG)\right) \times f(\ln(s_0), \ln(PG))$$

$$= \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \prod_{k \in \{\ln(s_0), \ln(PG)\}} \prod_{m=1}^{N_k} \underbrace{f_{\varepsilon_m^k}\left(Z_m^k - \iota_{m,0}^k - \iota_{m,1}^k k\right)}_{\text{Measurement system}} \underbrace{dF(\ln(s_0)|\ln(PG))}_{\text{skills in period 0}} \underbrace{dF(\ln(PG))}_{\text{skills for primary caregiver}} \tag{40}$$

where D_0 denotes the domain of s_0 and PG. The density of the measurement system is given by the normality assumption in Equation 31 and the parts corresponding for the skills in period 0, and the skills of the primary caregiver are given by the assumptions made in 32 and 33 respectively. For the second period, we not only integrate with respect to the factors of the period ($K_2 = \{e_2^{*,f}, e_2^{*,m}, I_2^*, s_2, \mu_2\}$). However, skills in the second period (s_2) also depend on skills in the first period (s_1) and so we integrate over the distribution of s_1 as well:

$$\int_0^{\infty} \int_{D_2} f_2(O_2, K_2, s_1|O_1, X;\Theta)\, dK_2\, d\ln(s_1) =$$

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$$\int \cdots \int \underbrace{\prod_{k \in K_2} \prod_{m=1}^{N_k} f_{\varepsilon_m^k} \left(Z_m^k - \iota_{m,0}^k - \iota_{m,1}^k k \right)}_{\text{Measurement system}} \times \underbrace{\prod_{j=m,f} f(\varepsilon_{w_2^j})^{\mathbb{1}\{h_j==1\}}}_{\text{wages}} \times \underbrace{f_{(v_2|\mu_2)} \left(v_t | \mu_2 \right)}_{\text{Pareto weight}} \times$$

$$\underbrace{f_{\left(\eta_{s_2} | K_2, \ln(s_1) \right)}}_{\text{Skills of child}} \times \underbrace{\prod_{k \in \{\ln(e_2^{f,*}), \ln(e_2^{m,*}), \ln(I_2^*)\}} f_{\eta_k}(\eta_k)}_{\text{density of first set of factors}} \times \underbrace{P_{\epsilon} \left(d_2^{m,*}, d_2^{*,f} \right)}_{\text{Preference shock}} dK_2 d\ln(s_1) \tag{41}$$

where D_2 is the support of the factors for the second period. The likelihood of the measurement system is determined by the distribution of the error terms introduced in Equation 31. The likelihood of the wages is given Mincer-type equation with a normally distributed error term as presented in Equations 37. The likelihood of the Pareto weight is given by the assumption of normality in the heterogeneity term v_2, as presented in Equation 36, and the relationship of the bargaining power and the distribution factors, as presented in Equation 6 .

The likelihood of the skills is given by the technology of skills formation (3) and the normality assumption of the heterogeneity term (35). The density of the factors is determined by the optimal solution of investment and effort, as presented in the Online Appendix, and the normality assumption in 34. $P_{\epsilon} \left(d_2^{m,*}, d_2^{f,*} \right)$ is the cdf of the preference shocks for the observed decisions taken by the household $\left(d_2^{m,*}, d_2^{f,*} \right)$ given by the cdf of a normal distribution. Note that we also integrate with respect to skills in the first period $\ln(s_1)$ since skills in the second period depend on skills in the first period.

A.2 Particle filter algorithm

Filtering Algorithm

1. Set t=0.

   (a) For rr=1....RR:

      i. draw $(\ln(s_0), \ln(PG))^{\{rr\}}$ from proposal distribution
         $g((\ln(s_0), \ln(PG)|\Theta, X)$

      ii. Compute the weights $\hat{w}_0^{\{rr\}} = \frac{1}{RR}$

   (b) Compute likelihood for measurement system in $t = 0$:
      $$\frac{1}{RR} \sum_{rr=1}^{RR} f\left(\{\{Z_m^{PG}\}_{m=1}^{N_{PG}}, \{Z_m^{s_0}\}_{m=1}^{N_{s_0}}\} | (\ln(s_0), \ln(PG))^{\{rr\}}\right)$$

2. Set t=t+1

   (a) For rr=1....RR:

      i. Draw $K_t^{\{rr\}}$ from proposal distribution (transition equation): $p(K_t^{\{rr\}} | K_{t-1}^{\{rr\}}, \Theta, X)$

      ii. For each factor, compute the corresponding weights given by the measurement system
         $$\tilde{w}_t^{\{rr\}} = \prod_{m=1}^{N_k} f_{\varepsilon_m^k}\left(Z_m^k - \iota_{m,0}^k - \iota_{m,1}^k k\right)$$

      iii. Define $w_t^{\{rr\}} = \hat{w}_{t-1}^{\{rr\}} \tilde{w}_t^{\{rr\}}$

   (b) For rr=1...RR

      i. Define $\hat{w}_t^{\{rr\}} = \frac{w_t^{\{rr\}}}{\sum_{rr=1}^{RR} w_t^{rr}}$

   (c) Compute the likelihood for period t: $\sum_{rr=1}^{RR} \tilde{w}_t^{rr} \hat{w}_{t-1}^{rr}$

   (d) For rr=1....RR

      i. Re-sample RR particles $K_t^{\{rr\}}$ from step (2.i) with probabilities $\hat{w}_t^{\{rr\}}$

      ii. Set $w_t^{rr} = \frac{1}{RR}$

In this application, I use as proposal $g((\ln(s_0), \ln(PG)|\Theta, X)$ the distribution characterized by the joint density of factors for period zero. The transition density from which factors in $t = 1, 2$ are drawn is characterized by the distribution of heterogeneity and the characterization of the factors given by the optimal solution of effort and investment in equations, the skill production specified and the Pareto weight specification.

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