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MATERNAL INVESTMENTS IN CHILDREN: THE ROLE OF EXPECTED EFFORT AND RETURNS*

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We investigate the importance of subjective expectations of returns to and effort costs of the two principal investments that mothers make in newborns: breastfeeding and stimulation. We find heterogeneity across mothers in rural Pakistan in expected effort costs and expected returns for outcomes in the cognitive, socio-emotional and health domains, and that this contributes to explaining heterogeneity in investments. We find no significant differences across women in preferences for child developmental outcomes. We simulate the impact of alternative policies on investments. Our findings highlight the relevance of interventions designed to address maternal depression and reduce perinatal fatigue alongside interventions that increase perceived returns to investments.

Gaps in children's intellectual, physical and emotional development emerge early in childhood and tend to widen over time (Cunha *et al.*, 2006; Ermisch *et al.*, 2012; World Bank, 2015). It is estimated that at least half of the variation across individuals in lifetime earnings arises from attributes determined by age 18 (Keane and Wolpin, 1997; Cunha *et al.*, 2005; Huggett *et al.*, 2011). Early childhood developmental outcomes are shaped by a combination of neurological, physiological and environmental factors, including nutrition, stress, and the responsivity and stimulation offered by parents and other caregivers. Parents thus play a crucial role, and differences in parental behaviours are an important facet of the emergence of unequal capabilities in children (Almond and Mazumder, 2013; Lavy *et al.*, 2016).

In the model of parental investments pioneered by Becker and Tomes (1979; 1986), heterogeneity in parental investments arises either from differences in resource constraints or from differences in parental preferences over child development. It can be difficult to modify preferences. Thus the traditional approach is to seek to ameliorate childhood inequalities through alleviation of poverty constraints, for example, through cash transfers.[1] However, the evidence that income transfers to poor families boost child outcomes is ambiguous, especially when the transfers are unconditional (Heckman and Mosso, 2014; Caucutt and Lochner, 2020). In other

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[1] The Mexican PROGRESA is an early example of a government-led programme offering conditional cash transfers to families, with the conditionality defined on parental investments in the health and education of children. This model has been adopted in numerous countries.

words, it is unclear that endowing low income parents with additional income translates into improved early childhood development.

We contribute to recent research highlighting the potential relevance of two additional constraints on parental investments—information frictions and effort costs. The Beckerian model assumes that parents have perfect information on how their investments influence child outcomes (henceforth, expected returns). We relax this assumption, allowing that parents with similar preferences and resource constraints may choose different levels of investment in their children because they have different subjective expectations (or beliefs) of the returns. If this is the case, interventions that offer information to mothers may redress early gaps in development. However, even if mothers update their beliefs about returns to their investments in children, effort costs may constrain investment. Effort costs may arise, for instance, from postnatal fatigue,[2] depression (Cohen *et al.*, 1982; Den Hartog *et al.*, 2003), or the cognitive load associated with poverty (Mullainathan and Shafir, 2013; Putnam, 2016). Failing to address these constraints may limit the effectiveness of a range of early childhood interventions. In a departure from existing studies of investments in children, we model effort cost directly. In doing this, we address a second limitation of traditional models of parental investments which interpret resource constraints as credit constraints, neglecting the relevance of mental and physical capacity constraints.

To investigate the role of information and effort costs, we elicit baseline data on expected returns and effort costs from a sample of more than 1,100 pregnant women in rural and peri-urban Pakistan. We measure investments when their children are three months old, focusing on exclusive breastfeeding and structured play. These are essential aspects of parenting and attachment creation in the first months of life. Parenting and attachment have been argued to be among the most critical family-level factors influencing human capital and social mobility (Heckman and Mosso, 2014).[3]

We elicit probabilistic beliefs about investment returns in terms of child development in various domains: cognitive (language and learning well at school), socio-emotional (playing with other children), and health (diarrhoea, the leading cause of death among infants and children in Pakistan). We elicit expected effort costs by asking mothers how tiring they anticipate the activities of breastfeeding and play to be.

We find that, in general women expect fairly large positive returns to their investments, but that there is substantial heterogeneity in expected returns.[4] Expected returns are increasing in education and wealth of the mother. We find no evidence that expected returns are lower among women suffering depression. Against the prior that women learn about returns to maternal investment by raising children, we see no gradient in birth order.

We find considerable variation in expected effort costs, with about a third of all pregnant women expecting breastfeeding or playing with their (unborn) child to be tiring. Depressed women report higher anticipated effort costs, as do women with no education and older women.[5] We see a positive association between expected returns and costs conditional on mother characteristics.

[2] It is estimated that it can take a mother a year or more to recuperate from the demands of pregnancy, and replenish stocks of vital nutrients (DaVanzo and Pebley, 1993).

[3] Fitzsimons and Vera-Hernández (2013) identify a positive causal impact of breastfeeding on cognitive development, and several other studies have associated breastfeeding with attachment (e.g., Britton *et al.*, 2006). Attanasio *et al.* (2020) identify impacts of structured play on cognitive development among toddlers.

[4] The largest returns to breastfeeding are for the child health outcome, and the largest returns to guided play are for cognitive outcomes, an indication that women understand both our questions, and the contributions of breastfeeding and play.

[5] For example, in a linear regression of expected cost on basic demographics, we find that depressed mothers are 8 percentage point (p.p.) more likely to expect that playing will be tiring ($p < 0.05$). Additionally, women with no education

This underlines the importance of collecting data on expected effort costs data alongside expected returns, as it indicates that omitting costs could lead to bias in the estimated role of expected returns (Wiswall and Zafar, 2015).

Turning to the data on maternal investment in children at 3 months of age, we find that 32% breastfeed, but do not guide play, 15% do not breastfeed, but guide play, 36% of mothers make neither investment, and only 18% make both investments. There are clear wealth and depression gradients in the joint investments. For instance, only 11% of depressed mothers, compared with 20% of non-depressed mothers make both investments. The difference is statistically significant (p-value = 0.002). The gradients in wealth are a bit smaller, but still large and precise (p-value = 0.060).

We combine the data on subjective expectations of returns and effort costs measured before any investment is made (baseline survey in pregnancy) with data on actual investments in breastfeeding and play (three months postnatal). Using these data, we estimate a structural model of investment choices under uncertainty, that allows us to identify preference parameters for child developmental outcomes and effort costs (Manski, 2004; Delavande, 2008). We use the structural parameters to simulate impacts of alternative policies that raise expected returns or lift effort costs.

Our main finding is that differences in expected returns and expected effort costs contribute to explaining the observed variation in maternal investments, but that differences in preferences for child developmental outcomes play a limited role. Our estimates indicate a role for maternal depression in hampering investments in children, as we find that depressed women report a higher perceived effort cost of investment, which exerts a significant dampening influence on investment in structured play. In line with previous research (Cunha *et al.*, 2013), our simulations suggest that an information intervention that increases the mother's expected returns raises both investments. Results by tertiles of baseline expected returns shows that women with lower expected returns are more responsive to information than women with higher baseline expectations.

We also provide the first evidence that eliminating effort costs leads to a significant increase in guided play (stimulation). Investment in play increases by 12% (3.8 p.p. from a baseline of 31%) in a simulation in which effort costs are set to zero.[6] Increasing expected returns while at the same time lifting effort cost shows the strongest potential to foster maternal investments.[7] In an alternative simulation, we investigate the effect of treating depression by setting an indicator for whether the mother is depressed to zero, and replacing the expected returns and costs reported by depressed mothers with the averages from the non-depressed sample. This results in an increase in investment in play of 8%, consistent with our finding that depression exacerbates effort costs, and that depressed mothers exhibit lower levels of investment.

Overall, our results contribute to the still scarce evidence in the literature that information interventions have the potential to raise parental investment in children, and they provide the first estimates showing that interventions that act to lighten the mental and physical load on new mothers, such as mothers groups or depression treatments, can foster child development.

A concern that runs through this literature is the potential endogeneity of beliefs. This may bias preference parameters on account of learning or *ex post* rationalisation (Delavande and Zafar,

exhibit a roughly 1 p.p. higher likelihood of expecting playing to be tiring compared to women with 1 to 5 years of education ($p < 0.1$) or women with 6 to 10 years of education ($p < 0.5$).

[6] As a comparison, raising the expected return of play by 40% of a standard deviation, a benchmark based on existing interventions, increases the probability of playing by 4.5%.

[7] This combined intervention is also effective at reducing differences in investment across mothers by education, wealth and depression status.

2019).[8] Our design mitigates this concern in two ways. First, beliefs are elicited in pregnancy before the child is born and before any investments are made. Second, the beliefs questions are framed in terms of what the respondent thinks the average woman in her community expects, rather than what she expects.[9] Similar concerns over endogeneity may arise with regard to effort costs. The actual effort cost is endogenous as it depends on the effort the mother chooses to make once the child is born. We use her subjective expectation of her future effort cost, elicited in pregnancy.

We subject the data and the estimates to a number of checks. As regards the primary data we gather, we check that women understand probabilities before we elicit expected returns, and we confirm that the elicited data respect the basic properties of probabilities.[10] We show that the expected returns and cost data are well behaved, being consistent with outcome realisations. In the baseline survey we elicited preferences directly, asking women how much they cared about each developmental outcome analysed. We show that our modelled estimates concur with the stated preference data.

As regards the analysis, we investigate sensitivity of the estimates to accounting for differences across women in time or physiological constraints (that could limit the extent to which their investments reflect their subjective expected returns) and to allowing for complementarity in the perceived returns of the two investments. We further investigate bootstrapping the standard errors and sensitivity to sample restrictions, weights, alternative definitions of guided play (leveraging multiple measures in the data), measurement error in beliefs and within-village correlation in elicited beliefs and effort costs. We also complement the standard goodness of fit test with an out of sample prediction. Our broad conclusions are robust to these variations. Finally, we present two methods for conducting counterfactuals that change expected returns. One method involves recovering and changing the structural parameters of the production function, while the other entails changing expectations directly. Our analysis reveals that the results are not sensitive to the chosen method.

Relation to the existing literature. Following recognition of the identification problem that arises because many combinations of preferences and expectations yield the same choice (Savage, 1954; Manski, 2004), a number of recent studies combine expectations data with choice data to better understand decision-making under uncertainty (Delavande, 2008; Arcidiacono *et al.*, 2012; Stinebrickner and Stinebrickner, 2012; Attanasio and Kaufmann, 2014; Stinebrickner and Stinebrickner, 2014*a*,*b*; Delavande and Kohler, 2016; Giustinelli, 2016; Wiswall and Zafar, 2018; Delavande and Zafar, 2019).[11] With some recent exceptions discussed next, this research has not studied the role of parental expectations in determining parental investment in children.

Cunha *et al.* (2013; 2022), Boneva and Rauh (2018), Attanasio *et al.* (2019a) and Attanasio *et al.* (2019b) are similar to us in eliciting beliefs about returns to parental investments but, in contrast to us, they do not elicit effort costs. Our approach also differs from these studies in eliciting

[8] For instance, mothers who value health will tend to engage in health investments, and thereby learn about their effectiveness and express this in higher expected returns (learning), or mothers who did not engage in health investments may tend to report low expected returns so as to rationalise their actions.

[9] Experimentally varying depression is interesting, but it would not independently identify the role of returns and costs because depression can influence both, see Section 1.

[10] We use visual aids following the approach developed by Delavande and Kohler (2009) and reviewed in Delavande (2014; 2023).

[11] An alternative approach to the direct use of expectations data is to rely on stated choices for multiple hypothetical scenarios as in Adams-Prassl and Andrew (2019). This approach delivers the population average of beliefs versus preferences by comparing parent responses to certain versus uncertain choices. It is therefore not appropriate when one wants individual-specific expectations to associate them with choices.

perceived returns in the health, cognitive and socio-emotional domains. With the exception of Biroli *et al.* (2018) who investigate parental beliefs about the returns to diet and exercise among children age 5–18 in the UK, existing research has focused on cognitive, education or earnings returns. Dizon-Ross (2019) elicits parental beliefs about the child's academic performance, rather than beliefs over the returns to investing in children.

Ours is the first analysis of effort costs of mothers in making early postnatal investments. In a broadly related manner, existing studies have shown that non-pecuniary factors or psychic costs influence (own) education decisions (Cunha *et al.*, 2005; Eisenhauer *et al.*, 2015; Navarro and Zhou, 2016; Boneva and Rauh, 2019; Delavande and Zafar, 2019).

A further contribution of our study is that it analyses the role of maternal subjective expectations of returns and costs in the context of child development in a low income population. It is plausible that this is where information frictions are greater and effort costs higher. While there is rather more work on belief elicitation in richer countries, Attanasio *et al.* (2019b) elicit subjective expectations of returns (but not effort costs) in Colombia.

Our finding that maternal depression elevates the perceived costs of playing with the infant child contributes to an emerging literature on depression and economic decision-making. In the US and Pakistani context, respectively, Ronda (2016) and Baranov *et al.* (2020) find that depression hinders maternal investments. Both studies suggest that effort costs may be important, but cannot test for this without data measuring effort cost. There is also no previous attempt to test whether depression biases beliefs over expected returns to investment.[12]

Why early infancy? Our focus on early infancy is an important feature of our study. We briefly elaborate its rationale here. The newborn child is particularly sensitive to environmental influences, including nutrition and stimulation, the two investments that we analyse (Barker, 1990; 1995; Bateson *et al.*, 2004; Almond *et al.*, 2018). There is a biological basis for this. The velocity of physical and cognitive growth is higher in infancy than at any later period in life, which makes the child hungry for resources. Any shortfall has relatively large impacts on development because this is a life stage of considerable developmental plasticity. In a context similar to ours (Bangladesh), Hamadani *et al.* (2014) show that significant cognitive delays between children of different socio-economic backgrounds are apparent as early as at the age of 7 months. Once differences in initial conditions develop, they tend to be 'self-productive' and to exhibit dynamic complementarity with subsequent investments, as a result of which inequalities widen with age (Cunha and Heckman, 2007; Sevim *et al.*, 2023).

Altogether, this makes early infancy a critical period for investment (Heckman and Kautz, 2014). Our focus on early infancy also facilitates a cleaner analysis by limiting the agency of the child (the relevance of which is discussed, for instance, in Heckman and Mosso, 2014), allowing us to isolate determinants of maternal investment using data on a mother's expectations of returns and effort costs.

The rest of this paper unfolds as follows. Section 1 sketches a model of early life investments. Section 2 describes the data collection framework. Section 3 details our measures of maternal beliefs, costs and investments. Section 4 describes the data. Section 5 specifies the empirical model and Section 6 reviews the estimates. Section 7 presents robustness checks. Section 8 provides results from alternative policy simulations targeting an increase in maternal investments in early life. Section 9 offers concluding remarks.

[12] De Quidt and Haushofer (2016) formalise the notion that depression leads to downward biased beliefs about returns to own (i.e., their productivity) which, in turn, leads to lower effort. This is a different test that we do not conduct—in our setting it would require data on women's perceptions of their own productivity or self-efficacy.

1. Theoretical Framework

In this section we sketch a simple model that motivates the data collection and the empirical analysis. Our focus is on understanding maternal investment, and how it varies with beliefs about the human capital production function, expectations of own effort costs, and preferences for child human capital. Ours is a low income setting with virtually no female labour force participation, so the opportunity cost of the mother's time is not a market wage but, instead, time and energy available for household production. Expectations are elicited from a pregnancy cohort of women, during pregnancy, and the investments are measured when the child is three months old. We analyse two binary investments that are relevant at this age, exclusive breastfeeding e_{i1} and stimulation through play e_{i2}. These investments are time rather than money intensive. The dimensions of human capital that we associate with these investments and with respect to which we elicit expected returns include preschool childhood health h_i, cognitive ability a_i, socio-emotional development s_i, and learning well at school l_i. We allow depression to influence maternal investments through multiple channels: preferences, beliefs about the technology of human capital formation, perceived psychic costs of investment, and through tightening constraints.[13]

We consider the investment decision of a mother i who has recently given birth. For simplicity, we assume that the newborn is the only (first) child in the household, but we relax this assumption in the estimation. The mother is characterised by her depression status $d \in [0, 1]$. The model is similar in structure and assumptions to models in the existing literature, for instance, Cunha *et al.* (2013) and Attanasio *et al.* (2019b). The important difference is that we make explicit the effort and time costs of investment, allowing that maternal depression can modify these costs, as well as other parameters of the model.

The mother's utility is additively separable and depends on household consumption c_i and her child's human capital $\theta_{1,i}$. Child human capital is multi-dimensional with mean zero, and is not fully observable to the mother. She can only observe whether her child's developmental outcomes are within the normal range by virtue of their reaching relevant milestones, i.e., whether $\theta_{1,i} > \Theta$. The mother invests in the child at the level E_i. Her utility is given in equation (1) by:

$$U_i(c_i, \theta_{1,i}, E_i) = \alpha_d ln(c_i) + \omega_{\theta d} I(\theta_{1,i} > \Theta) - \delta_d C_{E_i} + \varepsilon_{E_i}, \quad (1)$$

where α_d is the utility value of log consumption, $\omega_{\theta d}$ is the discounted utility associated with the child's human capital being in the normal range, denoted by $I(\theta_{1,i} > \Theta)$. In terms of costs, δ_d is the marginal cost of effort while C_{E_i} is the effort or psychic cost of engaging in the investments E_i, which captures the direct disutility from the investment that may arise from physical or psychological fatigue. ε_{E_i} is a random term which is individual and investment-specific, and unobservable to the econometrician.

The human capital production function is as follows:

$$\theta_{1,i} = \mu_0 + \mu_1\theta_{0,i} + \mu_2 E_i + \mu_i + \zeta_i, \quad (2)$$

where $\theta_{0,i}$ is the child's human capital endowment at birth, and μ_i and ζ_i denote mean-zero variables that are known and unknown, respectively, to the mother at the time the investment decision is made. μ_i captures maternal efficiency in producing child human capital, while ζ_i are

[13] For a discussion of the psychological foundations for these pathways, and a simple model in which the pathways we discuss are described, see model below and the appendix in Baranov *et al.* (2017). The model was removed from the published version of the paper (Baranov *et al.*, 2020).

unexpected shocks that influence child development, such as the onset of an illness. We assume linearity for exposition purposes, but our empirical analysis does not require this.[14]

The standard model assumes that individuals know the actual production function.[15] In light of accumulating evidence against this (see Section 1), we allow that each woman acts on her individual (subjective) expectations over the parameters describing returns to her investment. The production function that she perceives is given by:

$$\theta_{1,i} = \eta_{i,0} + \eta_{i,1}\theta_{0,i} + \eta_{i,2}E_i + \mu_i + \xi_i, \tag{3}$$

where $\eta_{i,j}$ are individual-specific beliefs about the production function and ξ_i is a zero-mean variable that captures beliefs uncertainty.

Based on the beliefs from (3), we can obtain in equation (4) the individual-specific subjective probability that a child's developmental outcomes will be within the normal range conditional on maternal investment E_i:

$$P_i(\theta_{1,i} > \Theta|E_i) = P(\xi_i > \Theta - \eta_{i,0} - \eta_{i,1}\theta_{0,i} - \eta_{i,2}E_i - \mu_i). \tag{4}$$

In a departure from the related literature, we allow that, before she undertakes the investment, the mother is also uncertain about the effort cost that it will entail, and holds expectations over these costs, denoted $\mathcal{E}_i[C_{E_i}]$. The mother's decision problem is to choose investment levels E_i that mazimise her subjective expected utility

$$\mathcal{E}U_i(c_i, \theta_{1,i}, E_i) = \alpha_d ln(c_i) + \omega_{\theta d} P_i(\theta_{1,i} > \Theta|E_i) - \delta_d \mathcal{E}_i[C_{E_i}] + \varepsilon_{E_i}, \tag{5}$$

subject to a budget constraint, expressed as:

$$c_i = y_i + wh,$$

where y_i denotes her non-labour earnings and h denotes the fixed time allocated to home production wh, where w measures the hourly rate of home production.

Assuming an interior solution, the mother maximises the expected utility given in equation (6):

$$\mathcal{E}U_i(c_i, \theta_{1,i}, E_i) = \alpha_d ln(y_i + wh) + \omega_{\theta d} P_i(\theta_{1,i} > \Theta|E_i) - \delta_d \mathcal{E}_i[C_{E_i}] + \varepsilon_{E_i}. \tag{6}$$

The model is rudimentary, designed to profile the decision-making process and to embed information on subjective expectations of returns and effort costs. In Section 7 we investigate whether our estimates are robust to relaxing assumptions embodied in the model.

1.1. *The Role of Depression*

Maternal depression, indexed $d \in [0, 1]$, is allowed to impact maternal investments through a number of channels (see Baranov *et al.*, 2017). The first is related to *preferences*. Depression may reduce enjoyment from consumption and child developmental outcomes, anhedonia (the inability to feel pleasure) being a common symptom of depression (Pizzagalli, 2014). This is modelled as α_d and $\omega_{\theta d}$ being systematically different for women who are depressed, and not.

[14] Existing work typically assumes CES or Cobb–Douglas production function (Cunha *et al.*, 2013; Attanasio, 2015), with some exceptions that also assume linearity (e.g., Tincani *et al.*, 2021) in the production of test score. For our purpose, the functional form is irrelevant because we elicit directly the expectations about the child reaching development milestone. Note also that the investments in our case are discrete.

[15] A branch of the literature seeks to identify and estimate the actual production function from data on child development. Our purpose, as we discuss now, is different.

The second channel is related to *expectations about the human capital production function*. Depression may make a mother more likely to believe that a given level of investment yields a lower probability of reaching a development milestone, in which case $P_i(\theta_{1,i} > \Theta | E_i)$ is systematically lower for depressed mothers. A reason for this pessimism may be that the mother underestimates her own capacity to move the child's developmental outcomes (MacLeod and Salaminiou, 2001; De Quidt and Haushofer, 2016).

The third channel is related to the *effort costs of investment*. Depression is associated with fatigue, which can increase the psychological and physiological cost of performing simple tasks (Cohen *et al.*, 1982; Den Hartog *et al.*, 2003), increasing the disutility from undertaking the investments. This could reflect in depressed mothers having a higher marginal cost of effort δ_d or in a given investment requiring more units of effort C_{E_i} when the mother is depressed.

Our survey data have the advantages of having screened all respondents for clinical depression, and having over-sampled women diagnosed as suffering perinatal depression. We do not have experimental variation in depression that can be leveraged to identify causal effects. Even if we did, this would not allow us to identify mechanisms—in order to identify the four different channels discussed above, we would need four instruments. We are, however, in the unique position of having primary data containing elicited measures of expectations of returns to and effort costs of investment. This allows us to illuminate two of the channels discussed above, which we explore further with policy simulations. By virtue of estimating preferences for child developmental outcomes, we are also able to illuminate any differences in preferences between women who are and are not depressed, and we find no significant differences.

2. Study Design

2.1. *Sample*

The data were collected in 2016–2017 as part of a longitudinal study tracking a pregnancy cohort of women and their births, in rural and peri-urban Pakistan. The study is called Bachpan, which means childhood in Urdu (Sikander *et al.*, 2019b).

The research team surveyed forty communities (clusters), identifying all women who were pregnant. Using the patient health questionnaire (PHQ-9), a clinical screen for depression, we recruited 570 women who were diagnosed as depressed and another 584 who were not, a total of 1,154 pregnant women. We over-sampled depressed women.[16] Baseline data were collected when the mothers were in their third trimester of pregnancy. The investment data were gathered in a follow-up survey conducted when the newborns were three months of age.

We describe the baseline data on expected returns and effort costs using the entire data set which, given a non-response rate of 5.6% on these questions, includes 1,090 women. Between the baseline and the three-month follow up, a maternal depression intervention was implemented on roughly one-third of all women (half of all depressed women). The intervention, cognitive behavioural therapy delivered through volunteer peers, led to a moderate effect on symptom severity and remission from perinatal depression during the three months after childbirth (Sikander *et al.*, 2019a). We hence exclude the intervention group in the analysis of investment behaviour, working with women who were depressed, but not treated, and women who were not

[16] We use a binary measure of maternal depression based on the PHQ-9 following the psychometric literature. Women were classified as depressed when their score was 10 or above. See Online Appendix B.2 for details.

depressed. This is a conservative choice, designed to allow that the treatment may have impacted women's expectations of returns and effort costs, with this not being reflected in our data, which were gathered when the women were pregnant. Importantly, we investigate the sensitivity of our results to this restriction. On account of dropping the intervention group for analysis of investments, and a 23% attrition rate between waves, the investment analysis is run on a sample of 626 women.[17]

To adjust for the oversampling of women with depression, we weight the data to account for the regional prevalence of maternal depression, which was 30%.[18] Our results are not sensitive to whether or not we use weights. Tables 1a and 1b provide descriptive statistics for the original unweighted sample, the baseline weighted sample and the 3-month weighted follow-up sample. Mothers are 26 years old on average, with a mean parity of 2.5 children including the current pregnancy, and about 30% of them are pregnant with their first child. They have, on average, about 8 years of completed education, around 33% of them have 5 or fewer years of education, and their labour force participation rate is 6%. The difference between the weighted and unweighted samples is primarily in depression levels (since the weights are designed to map the 30% depression prevalence of the study area) and in variables known to be associated with the incidence of maternal depression—namely education, wealth and parity.[19] Importantly, there are no statistically significant differences in variable means between the weighted samples at baseline and 3 months. Online Appendix A, Table A.1, presents descriptive characteristics by attrition status. Column 1 presents characteristics for women who are included in the 3-month sample and column 2 for women who are not. Demographic characteristics, as well as expected returns and effort costs are similar across the two groups, which allays the potential concern that the 3-month sample is a selected subset of the baseline sample of women.

The data are of high quality. The research team includes psychiatrists and epidemiologists who specialise in mental health, child development experts and economists familiar with eliciting probabilistic expectations. The authors have worked with the field research team for several years. The data were collected electronically using tablets, uploaded daily to the main server, and checked weekly for inconsistencies. The sampling and the data are described in Sikander *et al.* (2015) and Turner *et al.* (2016), also see Online Appendix B: Data.

3. Measuring Investments and Eliciting Beliefs

3.1. *Maternal Investments*

To measure exclusive breastfeeding, mothers were asked to list all the nutrients given to their child in the last 24 hours; see Online Appendix B for a complete list, and Online Appendix A, Table A.2, for a summary of feeding practices in our study area. Exclusive breastfeeding is defined as giving

[17] Attrition arises from 8% miscarriage/stillbirth, 1% of women not being surveyed due to the child's illness, and 14% of women not surveyed for other reasons, primarily that they were staying at the home of their mother in the early postnatal period.

[18] We first weight observations at baseline to account for the difference between the real prevalence of maternal depression and the share of depressed mothers in our sample. We use a second weight to account for the exclusion of mothers receiving the intervention when examining the link between maternal beliefs and investments at 3 months. The weights are constructed by post-stratification. In our sample, the two strata considered are depressed and non-depressed. The weights are constructed by adjusting the observations in each stratum such that, with independence of the sample used, the weighted prevalence of depression in the sample matches the overall depression rate in the study region.

[19] The Data Online Appendix B details the construction of the wealth measure.

Table 1a. *Baseline Sample Descriptives (Mother and Household Characteristics).*

	(1) Non-weighted	(2) Weighted at baseline	(3) Weighted at 3 months	(4) Diff (1)–(2)	(5) Diff (2)–(3)	(6) Diff (1)–(3)
Mother's age (years)	26.71	26.58	26.65	0.13	−0.07	0.06
	(4.54)	(4.44)	(4.51)	(0.19)	(0.20)	(0.20)
Mother's education (years)	7.70	8.04	8.03	−0.34*	0.00	−0.33*
	(4.48)	(4.45)	(4.48)	(0.19)	(0.20)	(0.20)
Husband's education (years)	8.63	8.83	8.90	−0.20	−0.07	−0.28*
	(3.42)	(3.38)	(3.30)	(0.14)	(0.15)	(0.15)
Parity	2.58	2.48	2.45	0.10*	0.03	0.13**
	(1.51)	(1.46)	(1.43)	(0.06)	(0.06)	(0.07)
Household's income (US dollars)	214.23	224.58	225.72	−10.35	−1.14	−11.49
	(170.30)	(177.32)	(181.18)	(8.74)	(9.72)	(9.56)
Mother normally works	0.06	0.06	0.06	0.00	0.00	0.00
	(0.24)	(0.24)	(0.23)	(0.01)	(0.01)	(0.01)
Woman is depressed	0.49	0.30	0.30	0.19***	0.00	0.19***
	(0.50)	(0.46)	(0.46)	(0.02)	(0.02)	(0.02)
Depression score	8.67	6.39	6.32	2.28***	0.06	2.35***
	(6.71)	(6.17)	(6.07)	(0.27)	(0.27)	(0.29)
High SES (above median)	0.50	0.54	0.55	−0.04**	−0.01	−0.05**
	(0.50)	(0.50)	(0.50)	(0.02)	(0.02)	(0.02)
Item non-response rate	0.06	0.06	0.06	−0.01	0.00	−0.01
	(0.23)	(0.24)	(0.24)	(0.01)	(0.01)	(0.01)
Mother's education (categorical)						
Education: 0 years	0.15	0.13	0.13	0.02	0.00	0.01
	(0.35)	(0.34)	(0.34)	(0.01)	(0.02)	(0.02)
Education: 1–5 years	0.20	0.18	0.18	0.02	0.00	0.02
	(0.40)	(0.38)	(0.38)	(0.02)	(0.02)	(0.02)
Education: 6–10 years	0.44	0.45	0.45	−0.01	0.00	−0.01
	(0.50)	(0.50)	(0.50)	(0.02)	(0.02)	(0.02)
Education: +10 years	0.22	0.24	0.24	−0.02	0.00	−0.02
	(0.41)	(0.43)	(0.43)	(0.02)	(0.02)	(0.02)
Parity (categorical)						
Child in womb: 1st	0.29	0.31	0.31	−0.02	0.00	−0.02
	(0.45)	(0.46)	(0.46)	(0.02)	(0.02)	(0.02)
Child in womb: 2nd	0.26	0.27	0.27	−0.01	0.00	−0.01
	(0.44)	(0.44)	(0.45)	(0.02)	(0.02)	(0.02)
Child in womb: 3rd or higher	0.45	0.42	0.42	0.03	0.00	0.03
	(0.50)	(0.49)	(0.49)	(0.02)	(0.02)	(0.02)
Stated preferences						
Importance speaking	0.63	0.64	0.63	−0.01	0.00	0.00
	(0.48)	(0.48)	(0.48)	(0.02)	(0.02)	(0.02)
Importance diarrhoea	0.67	0.67	0.66	0.00	0.00	0.01
	(0.47)	(0.47)	(0.47)	(0.02)	(0.02)	(0.02)
Importance playing	0.66	0.67	0.66	−0.01	0.00	0.00
	(0.47)	(0.47)	(0.47)	(0.02)	(0.02)	(0.02)
Importance learning	0.79	0.80	0.80	−0.01	0.00	−0.01
	(0.41)	(0.40)	(0.40)	(0.02)	(0.02)	(0.02)
Observations	1,154	1,154	871			

Notes: Stated preferences reflect the level of importance that mothers attach to the developmental milestones under study (putting 2–3 words together in speaking by age 2, the frequency of diarrhoea episodes, playing happily by age 3, and learning well in school) in promoting a child's development (mentally and physically) in the future, and depict the share of mothers that consider the specific milestone to be important or very important against unimportant, little important, or moderately important. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table 1b. *Baseline Sample Descriptives (Beliefs and Costs).*

	(1) Non-weighted	(2) Weighted at baseline	(3) Weighted at 3 months	(4) Diff (1)–(2)	(5) Diff (2)–(3)	(6) Diff (1)–(3)
Likelihood of putting 2–3 words in speaking by age 2						
If the mother exclusively breastfeeds for 6 months	0.70	0.70	0.70	0.00	0.00	0.00
	(0.30)	(0.30)	(0.31)	(0.01)	(0.01)	(0.01)
If the mother does not exclusively breastfeed for 6 months	0.39	0.39	0.39	0.00	0.00	0.00
	(0.25)	(0.25)	(0.25)	(0.01)	(0.01)	(0.01)
If the mother plays with the child frequently	0.74	0.74	0.73	0.00	0.01	0.01
	(0.28)	(0.28)	(0.29)	(0.01)	(0.01)	(0.01)
If the mother plays with the child rarely	0.42	0.41	0.41	0.00	0.00	0.00
	(0.24)	(0.25)	(0.25)	(0.01)	(0.01)	(0.01)
Likelihood of diarrhoea episodes						
If the mother exclusively breastfeeds for 6 months	0.25	0.25	0.25	0.00	0.00	0.00
	(0.25)	(0.26)	(0.26)	(0.01)	(0.01)	(0.01)
If the mother does not exclusively breastfeed for 6 months	0.64	0.64	0.64	0.00	0.00	0.00
	(0.30)	(0.30)	(0.31)	(0.01)	(0.01)	(0.01)
If the mother plays with the child frequently	0.35	0.34	0.35	0.01	−0.01	0.00
	(0.31)	(0.31)	(0.31)	(0.01)	(0.01)	(0.01)
If the mother plays with the child rarely	0.51	0.50	0.50	0.01	0.00	0.01
	(0.30)	(0.30)	(0.31)	(0.01)	(0.01)	(0.01)
Likelihood of playing happily by age 3						
If the mother exclusively breastfeeds for 6 months	0.73	0.73	0.73	0.00	0.00	0.00
	(0.28)	(0.28)	(0.29)	(0.01)	(0.01)	(0.01)
If the mother does not exclusively breastfeed for 6 months	0.41	0.41	0.41	0.00	0.00	0.00
	(0.25)	(0.26)	(0.26)	(0.01)	(0.01)	(0.01)
If the mother plays with the child frequently	0.75	0.75	0.75	0.00	0.01	0.00
	(0.28)	(0.28)	(0.28)	(0.01)	(0.01)	(0.01)
If the mother plays with the child rarely	0.43	0.43	0.43	0.00	0.00	0.00
	(0.24)	(0.24)	(0.24)	(0.01)	(0.01)	(0.01)
Likelihood of learning well						
If the mother exclusively breastfeeds for 6 months	0.75	0.75	0.75	0.00	0.00	0.01
	(0.29)	(0.29)	(0.30)	(0.01)	(0.01)	(0.01)
If the mother does not exclusively breastfeed for 6 months	0.41	0.41	0.41	0.00	0.00	0.00
	(0.24)	(0.24)	(0.25)	(0.01)	(0.01)	(0.01)
If the mother plays with the child frequently	0.78	0.78	0.77	0.00	0.01	0.01
	(0.28)	(0.29)	(0.29)	(0.01)	(0.01)	(0.01)
If the mother plays with the child rarely	0.43	0.43	0.42	0.00	0.00	0.00
	(0.24)	(0.24)	(0.24)	(0.01)	(0.01)	(0.01)
Expected return of breastfeeding						
On speaking	0.30	0.30	0.30	0.00	0.00	0.00
	(0.33)	(0.33)	(0.33)	(0.01)	(0.02)	(0.02)
On diarrhoea	0.39	0.39	0.39	0.00	0.00	0.00
	(0.37)	(0.38)	(0.38)	(0.02)	(0.02)	(0.02)
On playing happily	0.32	0.32	0.32	0.00	0.00	0.00
	(0.33)	(0.33)	(0.33)	(0.01)	(0.02)	(0.02)
On learning well	0.34	0.34	0.33	0.00	0.01	0.01
	(0.33)	(0.32)	(0.33)	(0.01)	(0.02)	(0.02)
Expected return of playing						
On speaking	0.33	0.33	0.32	0.00	0.01	0.00
	(0.31)	(0.32)	(0.32)	(0.01)	(0.01)	(0.01)
On diarrhoea	0.16	0.16	0.15	0.00	0.01	0.01
	(0.38)	(0.38)	(0.39)	(0.02)	(0.02)	(0.02)
On playing happily	0.31	0.32	0.31	0.00	0.01	0.00
	(0.29)	(0.29)	(0.29)	(0.01)	(0.01)	(0.01)
On learning well	0.35	0.35	0.34	0.00	0.01	0.00
	(0.31)	(0.31)	(0.31)	(0.01)	(0.01)	(0.01)
Costs of investments						
Breastfeeding is tiring	0.41	0.39	0.39	0.02	−0.01	0.02
	(0.49)	(0.49)	(0.49)	(0.02)	(0.02)	(0.02)
Playing is tiring	0.38	0.35	0.36	0.02	−0.01	0.02
	(0.49)	(0.48)	(0.48)	(0.02)	(0.02)	(0.02)
Either breastfeeding or playing is tiring	0.51	0.48	0.49	0.03	0.00	0.02
	(0.50)	(0.50)	(0.50)	(0.02)	(0.02)	(0.02)
Observations	1,154	1,154	871			

Table 1c. *Follow-up Sample Descriptives (Investments).*

	(1) Non-weighted	(2) Weighted at baseline	(3) Weighted at 3 months	(4) Diff (1)–(2)	(5) Diff (2)–(3)	(6) Diff (1)–(3)
Attrition rate	0.23	0.23	0.24	0.00	−0.01	−0.01
	(0.42)	(0.42)	(0.43)	(0.02)	(0.02)	(0.02)
Investments						
Exclusively breastfed last 24 hr	0.48	0.49	0.49	−0.01	0.00	−0.01
	(0.50)	(0.50)	(0.50)	(0.02)	(0.03)	(0.03)
Guided play	0.31	0.33	0.33	−0.02	0.00	−0.02
	(0.46)	(0.47)	(0.47)	(0.02)	(0.02)	(0.02)
Joint investments						
Not breastfeeding and not playing	0.37	0.36	0.36	0.01	0.00	0.01
	(0.48)	(0.48)	(0.48)	(0.02)	(0.02)	(0.02)
Breastfeeding and not playing	0.32	0.31	0.32	0.01	0.00	0.01
	(0.47)	(0.46)	(0.47)	(0.02)	(0.02)	(0.02)
Not breastfeeding and playing	0.15	0.15	0.15	0.00	0.00	0.00
	(0.36)	(0.36)	(0.36)	(0.02)	(0.02)	(0.02)
Breastfeeding and playing	0.16	0.18	0.18	−0.02	0.00	−0.02
	(0.37)	(0.38)	(0.38)	(0.02)	(0.02)	(0.02)
Observations	1,154	1,154	871			

only breast milk to the child. While 93% of mothers were breastfeeding their 3-month old baby, only 49% were exclusively breastfeeding (Table 1c).[20]

We fielded the Infant-Toddler Home Observation Measurement of the Environment (HOME) inventory questionnaire designed for children aged 0–3 (Cox *et al.*, 2002), which includes a question asking the mother whether she guides the child during play; see Online Appendix B: Data. We focused on structured play and this matches closely the investment portrayed in the expectation questions. The data reveal that 33% of mothers guided their children during play. We conduct robustness checks replacing this with multiple alternative items from the HOME inventory in Section 7.

3.2. *Expectations About the Human Capital Production Function and Effort Cost*

We measure expectations about the human capital production function by directly eliciting probabilities for whether a child will reach specified developmental milestones conditional on high and low levels of maternal investment. Eliciting expectations conditional on hypothetical behaviours has become standard (e.g., Dominitz and Manski, 1997; Delavande, 2008). Recent examples relating to skill production functions include Cunha *et al.* (2013), Boneva and Rauh (2018) and Cunha *et al.* (2022).

3.2.1. *Investments and outcomes*

The high and low levels of maternal investment were specified as exclusive breastfeeding for six months versus not, and playing frequently with the child to help her learn new things versus playing rarely. We queried beliefs over returns that manifest in four child developmental outcomes that are easily observable to mothers. These are experiencing frequent diarrhoea (health), putting

[20] To ensure adequate milk production, exclusive breastfeeding has to be consistent. As a result, feeding activities in the last 24 hours are unlikely to lead to significant misclassification error.

2–3 words together in speaking by age 2 (cognitive ability); playing happily with other children by age 3 (socio-emotional development) and learning well at school. Learning well at school is a future cognitive outcome that likely depends on all domains of early childhood development (Bhalotra and Venkataramani, 2013; Biroli, 2016).[21]

3.2.2. *Eliciting probabilities*

Respondents provided their answers using visual aids (Delavande, 2023). We used a card with equal-sized bars numbered 0 to 10, explaining that one block means one chance out of ten. We started with a preamble explaining and testing the notion of a probability, see Online Appendix B. An example of the wording of the belief elicitation is:

In your view, what is the likelihood that a child will put two–three words together in speaking by the age of 2 years:

(*i*) *If the mother plays with the child frequently to help them learn new things?*
(*ii*) *If the mother rarely plays with the child to help them learn new things?*

Thus we measure beliefs about the human capital production by asking probabilities. Cunha *et al.* (2013) and Attanasio *et al.* (2019b) instead ask mothers to report what they think the youngest and oldest age is at which a child will reach a milestone, an approach that requires additional steps to transform answers into probabilities.

We chose to elicit probabilities because it avoids these additional steps and allows us to remain agnostic regarding the women's beliefs about the functional form of the production function and its arguments. Moreover, probabilistic beliefs have been successfully elicited in many low income settings (e.g., Delavande, 2023), which gives us confidence in the quality of the data. There is some evidence that, even in developed countries, individuals find it difficult to provide a minimum and a maximum, as shown by the relatively high item non-response rate in Dominitz and Manski (2011). Cunha *et al.* (2022) compares the two methods, showing that both yield measures of beliefs that behave sensibly, for instance, being correlated with investments measured by the HOME score. They acknowledge that relying on probabilistic beliefs does not require additional assumptions and that the directly elicited probabilities are consistent with the predictions of the model. These beliefs appear however uncorrelated with the difficulty of the milestone considered in their context.

3.2.3. *Endowments*

In Cunha *et al.* (2013) and Attanasio *et al.* (2019b) the hypothetical scenarios vary both the investment levels, as we do, and also the child's endowment at birth. We abstract from birth endowments because mothers have limited opportunities to learn about their child's birth endowment in our setting, for example, birth weight is typically not measured and check-ups are unusual.[22]

[21] Bhalotra and Venkataramani (2013) leverage sharp implementation of a water chlorination policy that drove diarrhoea decline, showing that exposed cohorts do better on Raven tests and PISA school-based tests. Biroli (2016) shows that health influences early non-cognitive development which, in turn, positively influences the evolution of both health and cognitive function and that all facets of human capital display a high degree of persistence.

[22] This choice also considerably reduces the number of questions to respondents which is important, not only for pragmatic reasons, but also because it limits respondent's fatigue. To account for endowments, one would need to elicit expectations conditional on various endowments levels, which implies that the number of questions increases *n*-fold for *n* endowment levels.

3.2.4. *Individual versus community level production function parameters*

Our questions eliciting expected returns were framed with reference to a typical mother and child in the community, rather than with reference to the respondent and her unborn child. Thus we do not elicit the beliefs described in (3), but instead beliefs about the technology determining how investments influence child outcomes $\theta_{1,i} = \eta_{i,0} + \eta_{i,1}\overline{\theta_{0,i}} + \eta_{i,2}E_i + \overline{\mu_i} + \xi_i = \eta_{i,0} + \eta_{i,2}E_i + \xi_i$. The advantage of this is that the random variable μ_i in (3) is potentially correlated with unobserved mother or child characteristics, and this would bias our estimates. For example, Delavande *et al.* (2017) find that the difference in survival expectations for self and 'someone like you' is associated with self-reported health status. Other studies have adopted this approach for similar reasons (Cunha *et al.*, 2013; Boneva and Rauh, 2018; Attanasio *et al.*, 2019b). This is also what is relevant for policy as it is beliefs about the general technology that would be targeted by an information intervention. It was also relevant that, in our pilot study, women appeared more comfortable talking about a generic mother–child pair than about their unborn child.[23]

3.2.5. *Beliefs over the effort cost*

We elicited expected effort costs of investment by asking pregnant women to report on a qualitative scale how tiring they expected it would be to breastfeed or play with a baby, see Online Appendix B.

3.2.6. *Measuring beliefs in pregnancy*

Expectations of returns and effort cost were asked in pregnancy before any investments could be made. This eliminates the risk of feedback from investments to beliefs, such as learning and *ex post* rationalisation.

4. Descriptive Statistics

4.1. *Heterogeneity in Maternal Investments*

We estimate conditional associations of maternal investments, one at a time, with baseline values of the mother's depression status, education and wealth, using linear regression (Online Appendix A, Table A.3, columns 1–4). Mothers who are depressed in pregnancy or asset poor are significantly less likely to guide their 3-month old baby during play, possibly indicating that time and energy constraints are more likely to bind in these cases. Exclusive breastfeeding does not vary with any of these characteristics.

We now consider correlates of the joint investments as in our model. In our sample, 36% of mothers make neither investment, 32% breastfeed, but do not guide play, 15% do not breastfeed, but guide play, and only 18% make both investments (Table 1c). Depression and asset-poverty significantly lower the chances of mothers making both investments: 20% of non-depressed mothers in contrast to 11% of depressed mothers make both investments (p-value = 0.002), while 34% of non-depressed mothers and 41% of depressed mothers make neither investment

[23] At 36 months, we assessed expectations for children's outcomes at age 6 (specifically, school readiness, and willingness to share) based on varying levels of maternal investment in child directed speech (frequent versus rare). These questions were posed for both a typical mother–child pair in the community and for each participant's own specific pair. We found a high correlation (above 0.72) between beliefs about the generic and specific mother–child pairs. Additionally, self-reported self-efficacy for child-directed speech showed an equal correlation with beliefs about both pairs. This suggests that many women perceive the general process of skill formation in children, as well as their own child's development under their own investment, as similar.

(p-value = 0.082) (Figure 1); 20% of mothers with wealth above the sample median, in contrast to 15% with wealth below the median make both investments (p-value = 0.060), while 33% of wealthier mothers compared with 39% of less wealthy mothers make neither investment (p-value = 0.130). Conditional associations show the same patterns (Online Appendix A, Table A. 3, columns 5 and 6).

4.2. *Heterogeneity in Expected Returns*

The elicited expectations are displayed in Figures 2(a) and 2(b), which reveal considerable heterogeneity in expectations, with probabilities taking all values between 0 and 1. The modal answer is 1 in the high-investment scenario, and most respondents provide answers below 0.5 in the low-investment scenario (with the exception of expectations concerning impacts of breastfeeding on diarrhoea). Figures 3(a) and 3(b) transform the data into *expected returns* by taking the difference in expected outcomes between the high and low investment cases. Three tendencies emerge: (*i*) On average, women perceive positive returns to both investments: 74% to 82% of women report higher chances of positive child developmental outcomes with the high relative to the low investment level, and the expected returns are large, varying between 16 p.p. (for playing-diarrhoea) and 39 p.p. (for breastfeeding-diarrhoea).[24] (*ii*) Women expect breastfeeding to have larger impacts on child health (39 p.p. for diarrhoea) than on other outcomes. They expect playing to yield the largest gains in learning at school (35 p.p.) and speech development (33 p.p.). The differences are statistically significant. Women expect their input to play to have only limited impacts on child health—Figure 3(b) shows that 22% expect a zero return. (*iii*) There is a lot of variation in expected returns. Expected returns for breastfeeding-diarrhoea are 20 p.p. in the bottom and 60 p.p. in the upper quartile; expected returns for playing-learning are 10 p.p. in the bottom and 60 p.p. in the upper quartile.[25]

We examine how expected returns vary with depression and other characteristics of the mother in Online Appendix A, Tables A.4a and A.4b, and the corresponding distributions are in Figures 4. There is no evidence that depressed mothers hold systematically different beliefs.[26] We see an education gradient for most investment-outcome pairs and a wealth gradient for some, in line with the finding of Cunha *et al.* (2013) that women of low socio-economic status (SES) expect lower returns.[27] We might expect higher parity mothers to have different beliefs than those expecting their first child as they may have had the opportunity to learn from previous children. However, we find that beliefs of first-time mothers are in general not different from those of more experienced mothers. This is consistent with our sample living in dense communities where women help each other with childcare, making it less important to have had one's own child. In addition it is not

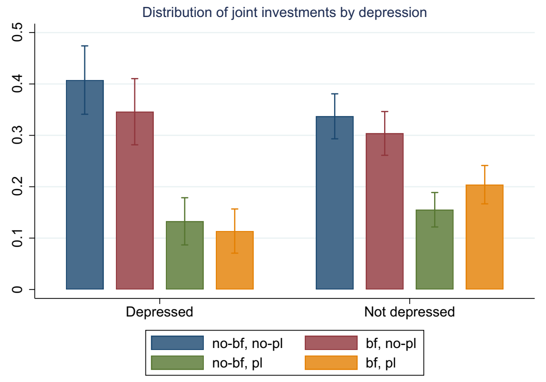
[24] An exception is that only 55% of mothers estimate a positive return to playing in terms of lower diarrhoea. We may have expected zero returns—why would play affect diarrhoea? Debriefing during the pilot revealed that some respondents thought that playing would, by increasing their time with the child, enable them to spot early signs of diarrhoea and act on them quickly.

[25] We acknowledge that respondents may round their expectations, in particular towards 0.5 and 1 (Giustinelli *et al.*, 2022). Rounding errors could lead to bias and reduce the precision of our estimates.

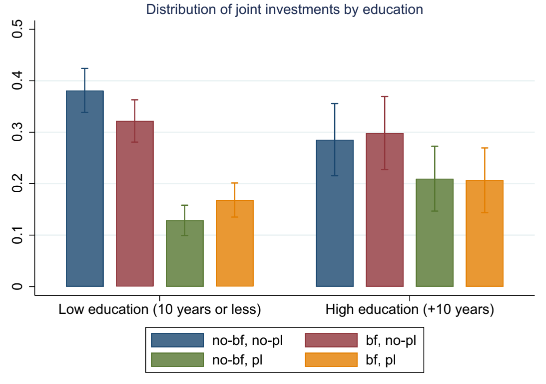
[26] We use a binary measure of maternal depression based on the PHQ-9 following the psychometric literature. Women were classified as depressed when their score was 10 or above. There is no gradient even if we use a different cut-off of the depression score (Online Appendix A, Tables A.5a and A.5b).

[27] The education gradient is essentially a difference between mothers with no education (15% of the sample) versus some education. For example, mothers with any education at all expect that exclusively breastfeeding for six months reduces the probability that a child experiences diarrhoea by 8.5 p.p. more than women with no education (Online Appendix A, Table A.4a, column 4). Wealth is measured as an index of asset ownership.

(a) By depression



(b) By education



(c) By SES

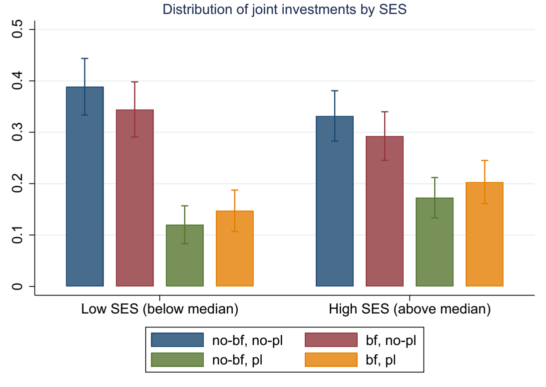


Fig. 1. *Joint Investments by (a) depression, (b) education and (c) SES.*
Notes: Joint investments: no-bf, no-pl = not breastfeeding and not playing; bf, no-pl = breastfeeding, but not playing; no-bf, pl = not breastfeeding, but playing; bf, pl = breastfeeding and playing. 95% confidence intervals displayed.

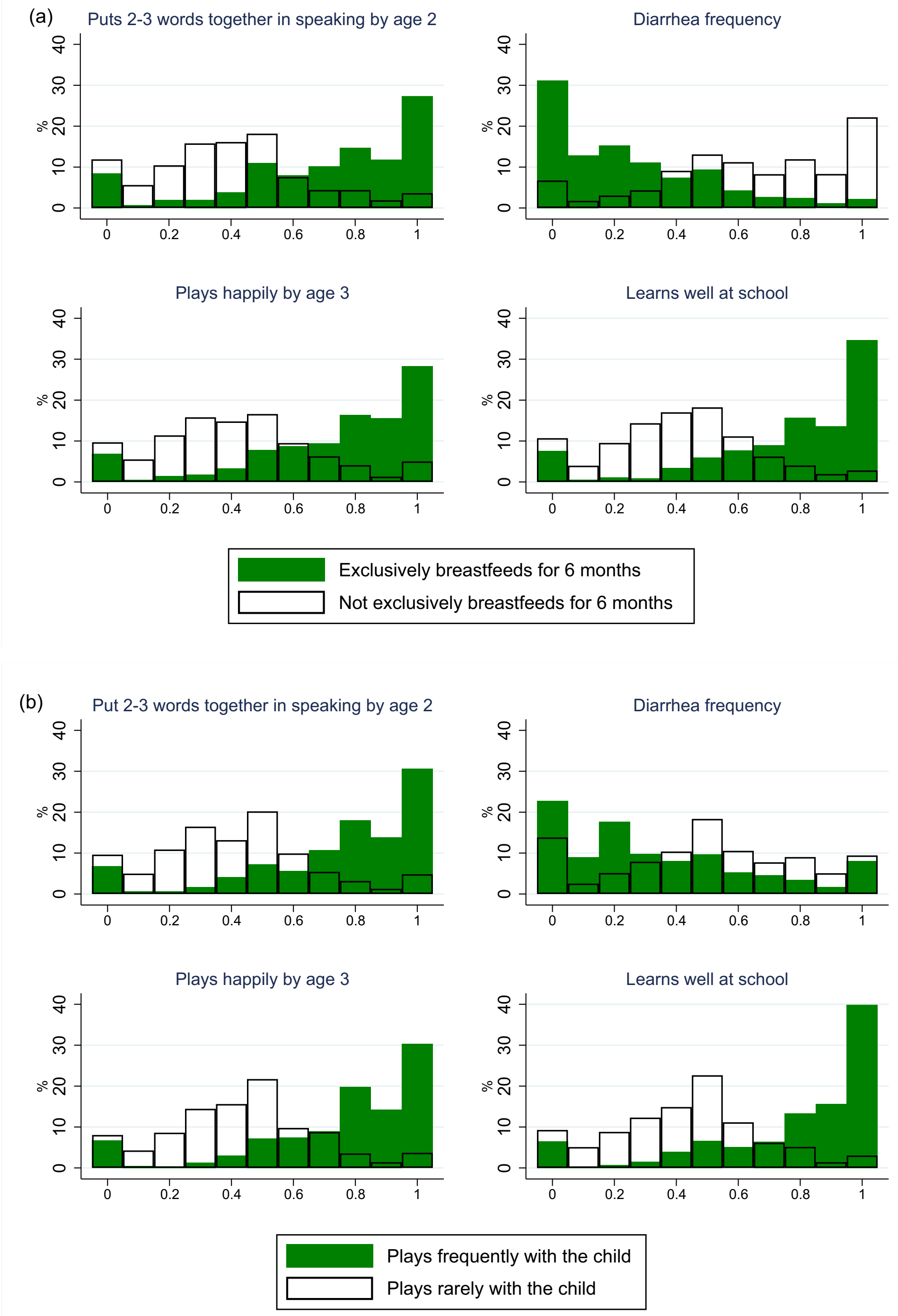


Fig. 2. *(a) Subjective Probabilities of Developmental Outcomes by Breastfeeding Investment Level. (b) Subjective Probabilities of Developmental Outcomes by Playing Investment Level.*

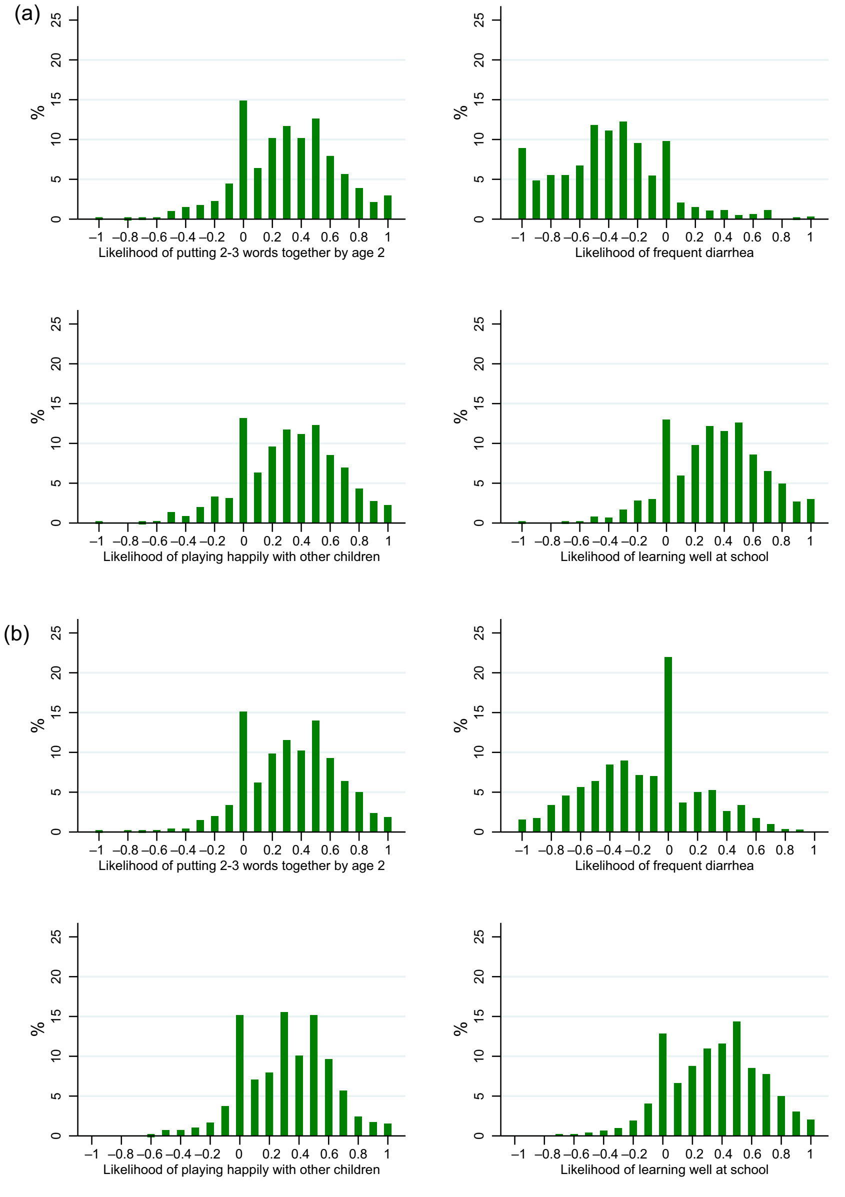


Fig. 3. *Expected Returns from Breastfeeding and Playing.*
Notes: (a) Expected return from exclusively breastfeeding: individual differences in the subjective probability of children achieving developmental outcomes when a mother exclusively breastfeeds for 6 months versus if a mother does not exclusively breastfeeds for 6 months. (b) Expected return from playing with child*:* individual differences in the subjective probability of children achieving developmental outcomes when a mother plays frequently with her child versus if a mother plays rarely with her child.

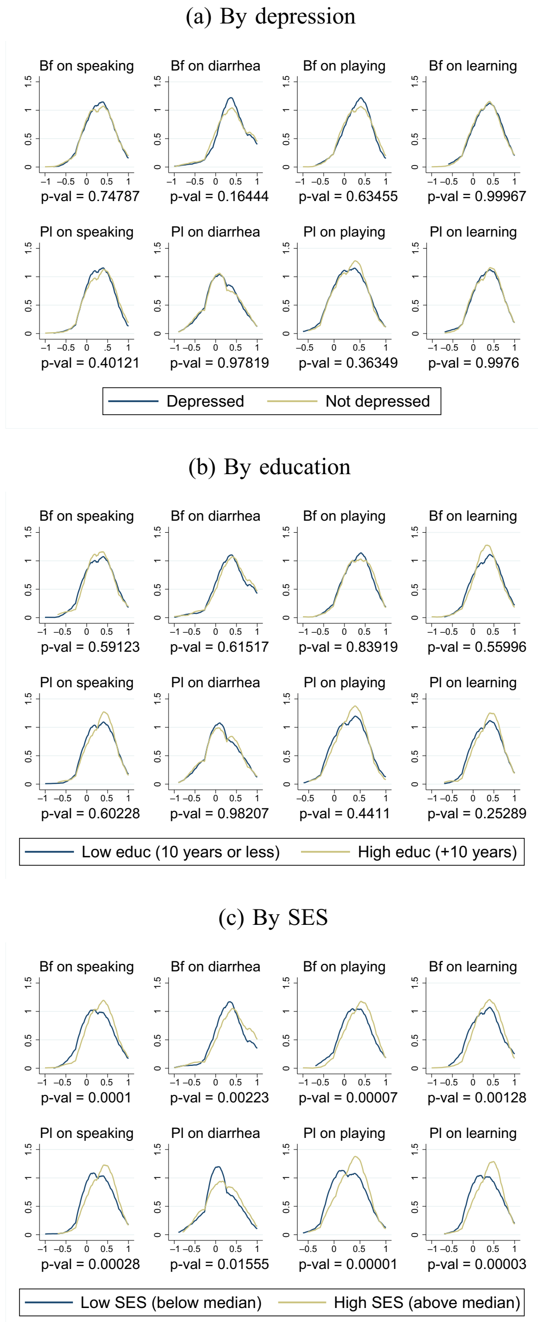


Fig. 4. *Expected Returns by Characteristics.*
Notes: Kernel distribution of individual differences in the subjective probability of children achieving developmental outcomes when a mother makes the high level investment versus when a mother makes the low level investment by (a) depression, (b) education and (c) SES. Bf is short for breastfeeding. Pl is short for playing. The p-val is the p-value of the two-sample Kolmogorov–Smirnov test for equality of distribution.

clear that having a first child delivers the sort of learning that will reflect in stated beliefs. This would require that the mother has had at least two previous children and made 'high' investments in one and 'low' investments in the other. Moreover, her older child may still be too young for her to have learnt through her own children how her investments translate into outcomes (the median birth interval is about two years). A lot of the heterogeneity in expectations is left unexplained by mother characteristics (R^2 in Online Appendix A, Tables A.4a and A.4b, is always below 0.05). This is typically the case with expectations data, even in other domains (Delavande, 2023).

4.3. *Data Quality Checks on Elicited Expected Returns*

First we compare reported beliefs against available benchmarks to assess their plausibility. Then we analyse item response rates, whether the data exhibit the basic properties of probabilities, and we look for commonly known flags of mistakes or limited attention.

There are no reliable estimates of the parameters of the actual production function for skills in this context for us to assess the accuracy of expected returns. Nevertheless, it is worth noting that the mean expectations for diarrhoea under the high investment closely mirror the diarrhoea prevalence figures from the Pakistan 2012–2013 Demographic Health Survey (DHS). Similarly, the mean expectations for language development are in close alignment with those of less educated women, as presented in the study by Cunha (2016) for a sample in the United States.[28] Although crude, these comparisons are indicative of data quality.

The item non-response rate is low, at 5.6%. The probabilistic answers respect the monotonicity property of nested events. This is clear from analysis of the practice question that we put to all women at the start of the expectations module. We asked what they thought the likelihood was of a woman in the community going to the market (*i*) in the next 2 days and (*ii*) in the next 2 weeks. The distribution of answers shows a clear shift of the distribution to the right when the time horizon increases, Online Appendix A, Figure A.1, consistent with women recognising that the probability of going to the market is higher the longer the time span allowed. Only 3.3% of respondents violated monotonicity. This is similar to results from other developing countries, and at the low end relative to developed countries (Delavande and Kohler, 2009; Delavande *et al.*, 2017).

We investigated the extent to which an individual woman provides the same answer to the series of probabilistic questions, as this is possibly an indication that she is paying limited attention.

Only 10% of women provided four or more repeat combinations of answers out of the eight outcome-investment combinations, and about 20% did not repeat any combinations, which is reassuring, see Online Appendix A, Figure A.2.

[28] The DHS show that 25–33% of children experienced diarrhoea in the two weeks prior to the interview, similar to the average expectation of mothers in our sample when the mother exclusively breastfeeds (25%), or guides play (35%) (Table 1b and Online Appendix A, Table A.7). In a US sample, Cunha (2016) find that 72% of children spoke partial sentences by age 2, which compares with 70–74% in our high investment scenario. Women in the US sample expect an 82% chance of a 2-year old speaking a 3-word sentence with high investment and high endowment, which is comparable to our sample. Expectations in the low investment and low endowment scenario in the US sample are also very similar to the expectations under low investments in our sample, at 46%. However, we cannot infer from the DHS what is the causal effect of breastfeeding on the children outcome and hence cannot evaluate accuracy of mothers' beliefs. This is because the DHS data is not longitudinal and because we lack credible exogenous variation in maternal investment.

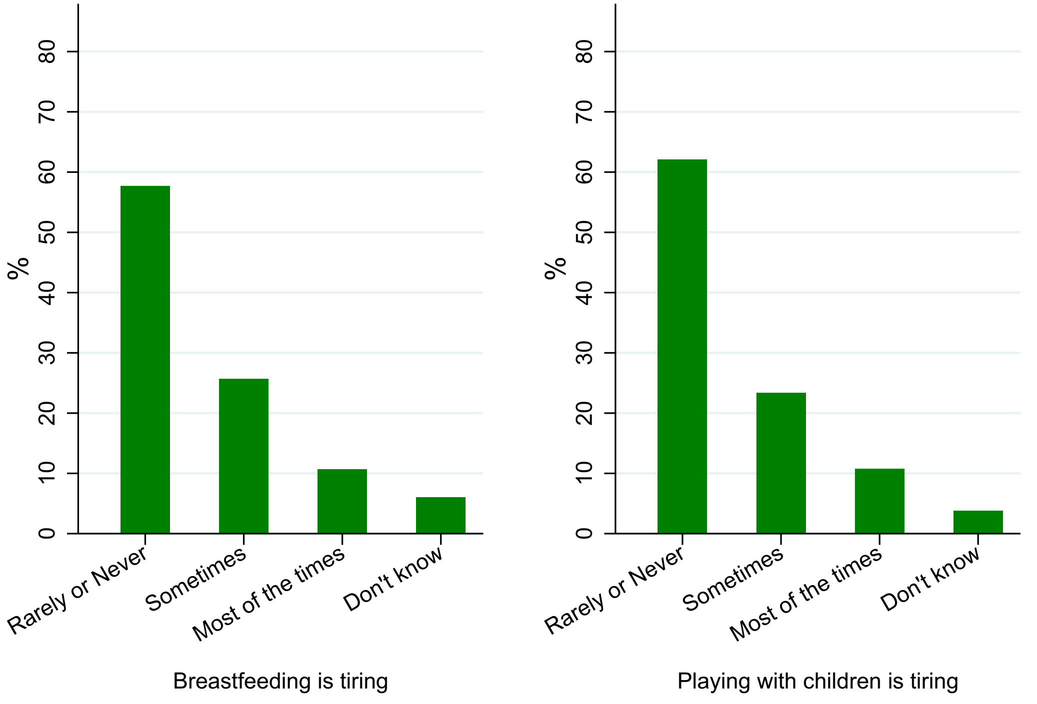


Fig. 5. *Distribution of Subjective Expectations of Effort Costs of Investment.*

We observe that 19% of women report a zero return for at least one investment-outcome pair, and these are more likely to be less educated women (Online Appendix A, Table A.6, column 3).

What is more worrying is that 22% of women report more than one negative return; these are again less educated and also poorer women. We investigate sensitivity of the estimates to excluding women who report negative returns (Section 7).

Overall, average probabilities of reaching specific milestones are consistent with available evidence on outcome realisations; women appear comfortable reporting probabilistic beliefs using the 10 bar score card; the vast majority of responses respect the basic properties of probabilities; we find a socio-economic gradient in expected returns to early life investments as has been found in other settings (e.g., Cunha *et al.*, 2013; Boneva and Rauh, 2018); and very few women repeat their answers. This gives us confidence in using the expected returns data in our empirical analysis.

4.4. *Expected Effort Costs of Maternal Investments*

We elicit effort costs using a Likert scale, but collapse the data to a binary indicator of whether the mother reports that the investment is either sometimes or most of the time tiring. We find that 39% and 35% of women anticipate finding breastfeeding and playing, respectively, and tiring (see Figure 5). There is a significant depression gradient in expected costs—depressed mothers are 9.7 p.p. and 8 p.p. more likely to expect that breastfeeding and playing respectively will

Table 2. *Effort Costs by Characteristics.*

	(1) Breastfeeding is tiring	(2) Breastfeeding is tiring	(3) Playing is tiring	(4) Playing is tiring
Education: 1–5 years	−0.078	−0.041	−0.142**	−0.094*
	(0.061)	(0.061)	(0.057)	(0.055)
Education: 6–10 years	−0.127**	−0.049	−0.212***	−0.107**
	(0.051)	(0.055)	(0.044)	(0.048)
Education: +10 years	−0.161***	−0.054	−0.246***	−0.096
	(0.058)	(0.069)	(0.054)	(0.059)
Age (years)	0.045	0.053	0.068**	0.073**
	(0.031)	(0.032)	(0.030)	(0.031)
Age squared	−0.001	−0.001	−0.001**	−0.001**
	(0.001)	(0.001)	(0.001)	(0.001)
Husband's education (years)		0.008		0.005
		(0.006)		(0.004)
Asset-based SES		−0.044***		−0.058***
		(0.014)		(0.014)
Child in womb: 2nd		−0.008		0.040
		(0.038)		(0.043)
Child in womb: 3rd or higher		0.028		0.019
		(0.036)		(0.039)
Woman is depressed		0.097**		0.080**
		(0.038)		(0.030)
Constant	−0.105	−0.356	−0.406	−0.630
	(0.394)	(0.411)	(0.396)	(0.415)
Observations	1,021	1,021	1,044	1,044
R^2	0.012	0.038	0.029	0.063

Notes: Results estimated with an OLS regression of expected effort cost of investments on mother's characteristics. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. Robust standard errors in parenthesis, clustered at the village level. Sample: All mothers.

be tiring (Table 2). This is consistent with the discussion in Section 1, where we highlight that fatigue may increase the direct cost of maternal investment.[29]

There are education and wealth gradients in expected effort costs. The wealth gradient in expected costs of investment is steeper than for expected returns, conditional on education.[30] Consistent with intuition, older mothers are more likely to expect playing to be tiring. The plausibility of these gradients increases confidence in the data.

Expected returns tend to be positively associated with expected costs, even after conditioning on mother characteristics (Online Appendix A, Table A.9). This goes against the idea that mothers who anticipate higher returns for an investment internalise the cost of the investment and do not view it as costly. It underlines the importance of collecting effort cost data alongside expected returns data because omitting costs might lead to biased estimates of the role played by expected returns (see Wiswall and Zafar, 2015). To investigate this, we re-estimated the model dropping expected costs of breastfeeding and play. The coefficient on returns is larger, albeit not significantly different.

[29] For unconditional associations on the complete Likert scale see Online Appendix A, Table A.8.

[30] Mothers with 6–10 years of education are 13 p.p. less likely to expect to feel tired from breastfeeding compared to mothers with no education, and 21 p.p. less likely to expect to be tired from playing. The education gradient in breastfeeding is attenuated when controlling for wealth, but the education gradient in playing persists. A one standard deviation increase in the wealth index is associated with a 7 p.p. lower likelihood of finding breastfeeding a tiring activity, 9 p.p. lower for the cost of playing.

5. Empirical Strategy

Recall that the mother's problem is to choose investment levels $E_i = (e_{i1}, e_{i2})$ that maximise her subjective expected utility, given in (5). The probability that mother i chooses investment levels $(e_{i1} = j_1, e_{i2} = j_2)$ conditional on beliefs P_i, expected cost $\mathcal{E}_i[C_{E_i}]$ and characteristics X_i, including non-labour income y_i and depression status d is given by:

$$Pr(e_{i1} = j_1, e_{i2} = j_2 | X_i, P_i, \mathcal{E}_i[C_{E_i}]) = Pr\Big[\mathcal{E}U_i(j_1, j_2) > \mathcal{E}U_i(t_1, t_2), \forall\, (t_1, t_2) \neq (j_1, j_2) | X_i, P_i, \mathcal{E}_i[C_{E_i}]\Big]. \quad (7)$$

We make some assumptions in order to be able to estimate (7). Although we are making inference using the expected probability distribution of joint investments $P_i(\theta_i|e_{i1}, e_{i2})$, women were asked their expected returns from individual investments, i.e., $P_i(\theta_i|e_{i1})$ and $P_i(\theta_i|e_{i2})$. We assume the mother sets the other investment at the modal value of the investments in the community (i.e., no playing and no exclusive breastfeeding). This assumption is motivated by the fact that the vast majority of respondents report the mode of their distribution of beliefs when asked for a point estimate (Delavande and Rohwedder, 2011). Our baseline specification assumes that there is no subjective complementarity between the investments, i.e., $P_i(\theta_i|e_{i1}, e_{i2}) = max(P_i(\theta_i|e_{i1}), P_i(\theta_i|e_{i2}))$, but we test the sensitivity of our results to this assumption in Section 7.

We also make some parametric assumptions. For the overall expected cost of effort, we assume:

$$\delta_d \mathcal{E}_i[C_{E_i}] = \delta_{1d} I(e_{i1} = 1) \cdot I_i(e_1 = c) \; + \; \delta_{2d} I(e_{i2} = 1) \cdot I_i(e_2 = c),$$

where $I(e = 1)$ is a binary indicator function equal to 1 if mother i engages in investment e and $I_i(e = c)$ is a binary indicator function equal to 1 if mother i expects investment e to be costly. This means, for example, that mother i expects to incur the cost δ_1 of breastfeeding if she breastfeeds and expects breastfeeding to be tiring. Similarly for the cost δ_2 of playing. Mothers who report that breastfeeding or playing is not tiring have a cost of zero.

We also assume that the utility depends linearly on some household characteristics X_i, including the mother's baseline depression status, age, education, parity, husband's education, a household-assets wealth index and the gender of the newborn. This captures systematic differences in investments by the mother's characteristics. With these assumptions, the woman's subjective expected utility is given by:

$$\begin{aligned}\mathcal{E}U_i(y_i, X_i, P_i, \mathcal{E}_i[C_{E_i}], e_{i1}, e_{i2}) = {} & \alpha_d ln(y_i) + \omega_{hd} P_i(h_i > \Theta_H | e_{i1}, e_{i2}) \\ & + \omega_{ad} P_i(a_i > \Theta_a | e_{i1}, e_{i2}) + \omega_{sd} P_i(s_i > \Theta_s | e_{i1}, e_{i2}) \\ & + \omega_{ld} P_i(l_i > \Theta_l | e_{i1}, e_{i2}) - \delta_{1d} I(e_{i1} = 1) \cdot I_i(e_1 = c) \\ & - \delta_{2d} I(e_{i2} = 1) \cdot I_i(e_2 = c) + \gamma_{e1,e2} X_i + \varepsilon_{E_i}, \end{aligned} \quad (8)$$

where, as discussed in Section 1, the developmental outcomes are early childhood health h_i, cognitive ability a_i, and socio-emotional development s_i, as well as learning well at school l_i. We estimate (8) using a multinomial logit model by assuming the random terms ε_{E_i} to be independent for every individual i and investment level $e = (e_{i1}, e_{i2})$ and with a Type I extreme value distribution. The four alternatives are: (*i*) neither breastfeed nor play with the child, (*ii*) breastfeed, but not play, (*iii*) play, but not breastfeed, and (*iv*) both breastfeed and play. The probability of choosing investment (j_1, j_2) is thus given by:

$$Pr(e_{i1} = j_1, e_{i2} = j_2 | y_i, X_i, P_i, \mathcal{E}_i[C_{E_i}]) = \frac{\exp V_i(y_i, X_i, P_i, \mathcal{E}_i[C_{E_i}], j_1, j_2)}{\sum_{t_1 \in (0,1), t_2 \in (0,1)} \exp V_i(y_i, X_i, P_i, \mathcal{E}_i[C_{E_i}], t_1, t_2)}, \quad (9)$$

where V_i is the expected utility maximised in (8), net of the ε_{E_i}. Using the beliefs and expected costs data, as well as actual investments, we make inference on the structural parameters $\omega_{j, j\in(h,a,s,l)}$, $\delta_{j, j\in(0,1)}$, $\gamma_{e1,e2}$.

Note that in our multinomial logit set-up, the utility associated with each investment varies with a set of attributes that are investment- and mother-specific (the beliefs and expected costs), as well as with mother-specific characteristics (the X_i). To create a parallel with the classic example of a multinomial choice model of transportation modes, the beliefs and expected costs are the 'attributes' of the maternal investments in the same way as cost and commuting time are the attributes of the transportation modes. For example, the health belief associated with the alternative $(e_{i1} = j_1, e_{i2} = j_2)$ is the subjective probability $P_i(h_i > \Theta_H | j_1, j_2)$ of not having diarrhoea under the investment $(e_{i1} = j_1, e_{i2} = j_2)$, which is derived directly from the elicited probabilities. The preference parameter ω_h, which is the coefficient associated with the subjective probabilities $P_i(h_i > \Theta_H | e_1, e_2)$ in our estimation, is identified (up to scale) using the variation in probabilities across investments and mothers. It captures how much mothers value the health of their children. The same applies to the other preference parameters $\omega_{j, j\in(a,s,l)}$. The cost parameters $\delta_{j, j\in(1,2)}$ are identified using the variation in expected effort costs across investments and mothers. The preference and cost parameters ω and δ are the same for all four investments.

The preference parameters $\gamma_{e1,e2}$, however, vary with the investment because the X_i are individual-specific and hence identical across investments. For identification, we need to normalise the $\gamma_{e1,e2}$ to zero for one alternative since only differences in utility matter (e.g., Train, 2009). We normalise the $\gamma_{e1,e2}$ for the alternative (*i*), neither breastfeed nor play. We present results with and without these demographic controls X_i. Note that $ln(y_i)$ is the same for all maternal investments and, therefore, the preference parameter for log consumption α_d is not identified.

While the multinomial logit model has been widely used for the modelling of multiple choices, its assumptions could prove demanding for our specification of joint investments. We address this concern by also estimating a mixed logit model that relaxes the Independence of Irrelevant Alternatives (IIA) assumption.

6. Results

6.1. *Parameter Estimates*

We start by estimating a simpler multinomial logit model in which there is no heterogeneity in preferences for child outcomes and in the marginal cost of effort by depression status ($\omega_{j1} = \omega_{j0}$ for $j = h, a, s, l$, $\delta_{11} = \delta_{10}$ and $\delta_{21} = \delta_{20}$). The estimates are in Table 3. We first show results assuming that mothers only value one of the four developmental outcomes (one at a time), and then present estimates allowing all developmental outcomes to enter the mother's utility function. The main results from this table are that (*i*) women who expect higher returns from a particular investment are more likely to engage in that investment; and (*ii*) mothers who find playing costly are less likely to play. Thus subjective maternal expectations over both returns and costs influence key early life investments in children.

Table 3. *Baseline Model Estimates of the Preference and Cost Parameters.*

	Speak		Health		Social		Learn		All outcomes	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ω_speak	0.582**	0.528**							0.234	0.192
	(0.249)	(0.241)							(0.361)	(0.340)
ω_health			0.209	0.195					0.040	0.039
			(0.265)	(0.254)					(0.275)	(0.268)
ω_social					0.401*	0.389			−0.358	−0.289
					(0.224)	(0.245)			(0.353)	(0.367)
ω_learn							0.931***	0.849***	1.003***	0.901***
							(0.229)	(0.241)	(0.333)	(0.345)
Breastfeeding is tiring	0.202	0.213	0.195	0.204	0.201	0.211	0.232*	0.240	0.232*	0.240
	(0.132)	(0.145)	(0.131)	(0.145)	(0.131)	(0.144)	(0.134)	(0.148)	(0.134)	(0.148)
Playing is tiring	−0.690***	−0.610***	−0.722***	−0.638***	−0.703***	−0.621***	−0.674***	−0.596***	−0.675***	−0.597***
	(0.185)	(0.191)	(0.180)	(0.188)	(0.179)	(0.189)	(0.180)	(0.189)	(0.183)	(0.191)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	2,504	2,504	2,504	2,504	2,504	2,504	2,504	2,504	2,504	2,504
# mothers	626	626	626	626	626	626	626	626	626	626

Notes: Results estimated using a multinomial logit model where mother's alternatives are: no-bf, no-pl = not breastfeeding and not playing; bf, no-pl = breastfeeding, but not playing; no-bf, pl = not breastfeeding, but playing; bf, pl = breastfeeding and playing. The model includes a constant and the investment alternatives are evaluated against not breastfeeding and not playing (omitted category). ω_speak = preference parameter for a child being able to put 2–3 words together in speaking by age 2. ω_health = preference parameter for a child not experiencing frequent diarrhoea. ω_social = preference parameter for a child playing happily with other children by age 3. ω_learn = preference parameter for a child learning well at school. Controls include the age of the mother and its square, the sex of the index child, 3 levels of parity (first child in womb, second, and third or higher), 4 levels of mother's education (no education, 1–5 years, 6–10 years, and +10 years), husband's education in years, an SES asset-based index, and a dummy for being diagnosed as depressed at baseline. See Online Appendix A, Table A.10, for the coefficients.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Robust standard errors in parenthesis, clustered at the village level. Sample: Excludes depressed mothers in the intervention group.

First, consider results for the ability to speak (columns 1–2). The preference parameter ω_s (the coefficient associated with beliefs about how much breastfeeding and playing influence the ability to speak) is positive and statistically significant. This shows both that maternal investments are determined by the mother's subjective beliefs about returns *and* that they care about this developmental dimension. The estimated cost of playing, δ_2, is negative and significant, revealing that mothers who find playing costly are less likely to play. The estimated cost of breastfeeding, δ_1, is not statistically different from zero, suggesting that the cost of breastfeeding is not a deterrent to exclusively breastfeeding a newborn at the age of 3 months in our sample.

Columns 3–8 of Table 3 show the estimates when we consider each of the other child developmental outcomes individually. The preference parameter for health (diarrhoea incidence) is positive, but about one-third smaller than the preference parameter for speaking, and is not precisely estimated. The preference parameter for socio-emotional development (the child playing happily with other children by age 3), is positive, only slightly smaller than the one associated with speaking, and borderline significant. The preference parameter for learning is the largest, and statistically significant at 1%.

Controlling for mother-level covariates does not change the magnitude or precision of the preference and marginal cost of effort parameter. In fact, once we condition on expected returns and effort cost, maternal characteristics explain little of the variation in investments, see Online Appendix A, Table A.10. Women diagnosed with depression are less likely to make both investments (even after conditioning on beliefs and effort cost). Wealthier women are more likely to make both investments as opposed to neither. We do not find that child gender influences neonatal investments; son preference in investment may manifest at a later age.

We next estimate (9) by considering the child's health, cognitive, psycho-emotional, and learning outcomes jointly in the decision-making process, see Table 3, columns 9–10. Now only the preference parameter for learning well at school is statistically significantly different from zero at 1%. A reason for the dominance of this outcome may be that it captures impacts of the other outcomes which occur pre-school.

Importantly, the ordering of the estimated preference parameters is in line with self-reported valuations of developmental outcomes that we elicited. In our sample, 80% of mothers responded that the ability of a child learning well is very important for a child's development, in contrast with a share of 64% to 67% for the other outcomes (Table 1a), and this difference is statistically significant at the 1% level.

In all specifications in Table 3, we find a negative and precisely estimated cost for playing, while the cost for breastfeeding is not precisely estimated.

6.2. *Goodness of Fit*

We assess the fit of the estimated model by comparing actual investments to the model-predicted probability of the investments. The model fit is very good, not only overall but, importantly, for a number of subsamples. It also performs well out-of-sample, when we estimate the model using a randomly selected two-thirds of the sample and predict investment for the remaining one-third of the sample, see Online Appendix A, Table A.11.

6.3. *Choice Elasticity*

We now use the model parameter estimates to analyse the predicted responsiveness of investment choice to changes in expected returns and costs. We focus on the specification that estimates the

Table 4. *Elasticities of Investments to Beliefs on Learning and to Cost of Playing.*

Learn Investment choice (change in %)	BF return (1% increase)	PL return (1% increase)	Joint investments return (1% increase)	Not investing return (1% increase)	Playing cost (1% increase)
Pr(no-bf, no-pl)	−0.23	−0.10	−0.12	0.28	0.06
Pr(bf, no-pl)	0.47	−0.10	−0.12	−0.17	0.06
Pr(no-bf, pl)	−0.23	0.62	−0.12	−0.17	−0.15
Pr(bf, pl)	−0.23	−0.10	0.62	−0.17	−0.15

Notes: Predicted probabilities estimated after a multinomial logit model that evaluates the preference for developmental outcomes jointly and where mother's alternatives are: no-bf, no-pl = not breastfeeding and not playing; bf, no-pl = breastfeeding, but not playing; no-bf, pl = not breastfeeding, but playing; bf, pl = breastfeeding and playing. Estimates of the model are shown in Table 3, column 10. BF is short for breastfeeding. PL is short for playing.

preference parameters for all developmental outcomes jointly (Table 3, column 10), and report results for expected returns in terms of the probability of a child learning well at school.

Results are in Table 4. A 1% increase in the expected return to breastfeeding increases by 0.47% the predicted probability that a woman decides only to breastfeed, and reduces the probability of neither breastfeeding nor playing by 0.23%. A 1% increase in the expected return to playing with the child increases the predicted probability of playing by 0.62%, which is the same increase in the probability of making both investments when the expected return from both increases by 1%. These elasticities are slightly higher than elasticities of school choices to expected earnings (0.12) and employment probability (0.34) found in Pakistan (Delavande and Zafar, 2019).

We next look at the elasticity of investments to expected costs (last column of Table 4). A 1% increase in the cost of playing (playing becomes more tiring as opposed to not tiring) reduces the predicted probability of a mother playing with the child by 0.15% (irrespective of whether or not she also breastfeeds). Since we found no evidence that the perceived costs of breastfeeding influence mother's choices, we do not explore responsiveness to this cost. There are no previous studies on the elasticity of maternal investment with respect to perceived costs.

6.4. *Heterogeneity in Preferences*

So far, we have assumed that all mothers have the same preference parameters for child development ω_j and marginal cost of effort parameters δ_j. We now relax this assumption to evaluate whether heterogeneity in preferences over child developmental outcomes and effort cost explains heterogeneity in investment decisions. We interact the expected returns and marginal cost of effort with mother characteristics, allowing ω_j, δ_1 and δ_2 to differ by characteristics. In Table 5, column 1, we find limited evidence of heterogeneity in preferences and in the marginal cost of effort by depression.[31] We similarly find limited evidence of heterogeneity by the mother's education and SES (columns 2 and 3).

Our measure of the effort cost of breastfeeding is the result of a question asking the mother how likely she thinks it is that she will find breastfeeding tiring. This will capture the absolute cost. One might expect that it is the relative cost that matters, which will depend on costs associated with bottle preparation (obtaining clean water, purchasing baby formula). If wealthier families face lower material costs of bottle feeding, the absolute cost will align more closely with the relative cost for them. However, we cannot reject that the cost parameters associated with

[31] There is a statistically significant difference in the health preferences parameter by depression status, but the estimates for each group are not statistically significantly different from zero.

Table 5. *Heterogeneity in the Preference Parameters.*

	(1) Depression	(2) Education	(3) SES
ω_speak × 1[low charac.]	0.101	0.110	0.944*
	(0.431)	(0.374)	(0.511)
ω_speak × 1[high charac.]	0.488	0.559	−0.396
	(0.460)	(0.903)	(0.480)
ω_health × 1[low charac.]	0.386	−0.271	−0.654
	(0.337)	(0.307)	(0.448)
ω_health × 1[high charac.]	−0.611	0.818	0.597**
	(0.399)	(0.704)	(0.298)
ω_social × 1[low charac.]	−0.264	−0.235	−0.419
	(0.496)	(0.433)	(0.573)
ω_social × 1[high charac.]	−0.472	−0.569	−0.095
	(0.771)	(0.752)	(0.537)
ω_learn × 1[low charac.]	0.563	0.846**	0.712
	(0.469)	(0.395)	(0.554)
ω_learn × 1[high charac.]	1.651***	1.383*	0.870*
	(0.574)	(0.768)	(0.470)
Breastfeeding is tiring × 1[low charac.]	0.156	0.455***	0.312
	(0.199)	(0.163)	(0.252)
Breastfeeding is tiring × 1[high charac.]	0.513**	−0.412	0.146
	(0.212)	(0.302)	(0.206)
Playing is tiring × 1[low charac.]	−0.450*	−0.439*	−0.845***
	(0.248)	(0.229)	(0.219)
Playing is tiring × 1[high charac.]	−0.973**	−1.043**	−0.423
	(0.437)	(0.421)	(0.258)
Controls	Yes	Yes	Yes
p-value: ω_speak[low charac.] = ω_speak[high charac.]	0.537	0.638	0.062
p-value: ω_health[low charac.] = ω_health[high charac.]	0.050	0.172	0.016
p-value: ω_social[low charac.] = ω_social[high charac.]	0.841	0.716	0.695
p-value: ω_learn[low charac.] = ω_learn[high charac.]	0.169	0.529	0.826
p-value: bf tiring[low charac.] = bf tiring[high charac.]	0.219	0.012	0.636
p-value: pl tiring[low charac.] = pl tiring[high charac.]	0.346	0.228	0.156
Observations	2,504	2,504	2,504
# mothers	626	626	626

Notes: Results estimated using a multinomial logit model where mother's alternatives are: no-bf, no-pl = not breastfeeding and not playing; bf, no-pl = breastfeeding, but not playing; no-bf, pl = not breastfeeding, but playing; bf, pl = breastfeeding and playing. The model includes a constant and the investment alternatives are evaluated against not breastfeeding and not playing (omitted category). ω_speak = preference parameter for a child being able to put 2–3 words together in speaking by age 2. ω_health = preference parameter for a child not experiencing frequent diarrhoea. ω_social = preference parameter for a child playing happily with other children by age 3. ω_learn = preference parameter for a child learning well at school. Controls include the age of the mother and its square, the sex of the index child, 3 levels of parity (first child in womb, second, and third or higher), 4 levels of mother's education (no education, 1–5 years, 6–10 years, and +10 years), husband's education in years, an SES asset-based index, and a dummy for being diagnosed as depressed at baseline. Column 1 interacts beliefs and costs by depression status (high characteristic = depressed). Column 2 interacts beliefs and costs with education level (high characteristic = +10 years of education). Column 3 interacts beliefs and costs with SES level (high characteristic = SES above median). $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. Robust standard errors in parenthesis, clustered at the village level. Sample: Excludes depressed mothers in the intervention group.

breastfeeding are the same for low and high SES families (Table 5). This is consistent with the cost of breastfeeding not playing an important role in the breastfeeding decision.

We explore heterogeneity in preferences more flexibly by estimating a mixed logit model where the parameters ω_j are assumed to have a normal distribution. The mixed logit relaxes the Independence of Irrelevant Alternatives (IIA) imposed by the multinomial logit. We continue to find no heterogeneity in preferences for child development, as we cannot reject the hypothesis that the variance of the normal distribution of ω_j is zero, see Online Appendix A, Table A.12. This is consistent with the results in Table 5, and with there being no gradient in self-reported preferences by depression, wealth and education (with the exception of lower diarrhoea being perceived as more important to more educated women), see Online Appendix A, Table A.13.

All in all, the results point to limited if any systematic differences in mother's valuations of child development outcomes and marginal cost of effort. This is in contrast to Cunha (2016), who finds that white parents value children developmental outcomes significantly more than black parents in the United States based on hypothetical choice questions.

6.5. *The Role of Depression*

In Section 1 we laid out the channels through which depression potentially impacts maternal investments. We now consider what light our estimates shed on this. We found no heterogeneity by depression status in elicited beliefs over investment returns (Section 4), and similarly none in preferences for child development (Table 5). We do, however, find evidence consistent with depression raising the perceived effort cost of making investments. Depression, being associated with fatigue, could be associated with a higher marginal cost of effort δ_d and/or higher effort C_{E_i} per investment. The heterogeneity analysis above refutes the idea that the marginal cost of effort δ_d differs by depression status. But analysis of the expected effort cost data in Section 4 shows a clear depression gradient in C_{E_i}. This, coupled with the fact that the marginal cost of effort (for playing) is an important determinant of investment suggests that depressed mothers invest less in their children because of their elevated expected effort cost. The cost of delivering the cognitive behavioural therapy through volunteer peers to the mothers is estimated at USD133 per participant (Sikander *et al.*, 2019a). Our simulations (to follow) show that treating maternal depression (in the subset of the 30% of women diagnosed with depression in pregnancy) leads to an increase in investments in children—a 7.9% increase in breastfeeding and 34.6% in playing. Estimates of both the benefit–cost ratio and the marginal value of public funds for these sorts of pre-school investments in health and education tend to exceed 5 (Hendren and Sprung-Keyser, 2020).

7. Robustness Checks

We briefly discuss validation and specification checks here, relegating details and all results to Online Appendix C.

7.1. *Investments Constraints*

We consider time and physiological constraints on breastfeeding. The maximisation problem stated in (8) assumes an interior solution. If women were constrained in their investment choices, they may not be able to act on their subjective expected returns. In this case, the coefficient associated with the beliefs would not be precisely estimated. However, this is not what we see in Table 3. Still, if some women are more constrained than others, the coefficients we estimate may be biased.

We investigate this by allowing the coefficients associated with beliefs (ω) to vary with the a priori likelihood that a mother experiences time constraints, using three proxies for this (Online Appendix C). We find no evidence of binding time constraints (Online Appendix C, Table C.1).

We have also implicitly assumed that exclusive breastfeeding is a choice. To investigate physiological constraints we leverage variation in food poverty and women's weight, but find no evidence that this variation influences investments (Online Appendix C, Table C.2).

7.2. *Complementarity of the Investments*

The baseline estimation assumes no (subjective) complementarity of the investments. A potential concern is that respondents believe that they could achieve more than the $max(P_i(\theta_i|e_{i1}), P_i(\theta_i|e_{i2}))$ when both investments are high. We relax our baseline assumption and introduce complementarity with the parameter σ as follows: $P_i(a_i|e_{i1} = 1, e_{i2} = 1) = max\big(P_i(a_i|e_{i1} = 1), P_i(a_i|e_{i2} = 1)\big) + \sigma min\big(P_i(a_i|e_{i1} = 1), P_i(a_i|e_{i2} = 1)\big)$. We assessed this assumption by interviewing a small sample of women after the main data set was collected.

We estimate that mothers expect a complementarity among investments σ of 1.8%. We replicate our main results with the estimated σ of 1.8% and, to analyse sensitivity to alternative values, also set σ to 5% and 10%, see Online Appendix C, Table C.3. The model estimates are very similar to those from the baseline specification independently of the level of complementarity assumed.

7.3. *Sensitivity to Sample*

We have so far excluded from the analysis sample women who were treated for depression with psychotherapy that emphasised positive thinking and encouraged positive thoughts about their baby. Our concern was that the intervention might have directly encouraged women to increase their investments in children, or that it may have led to systematic changes in expected returns and effort costs after our baseline survey conducted in pregnancy. To see how much this matters, we re-estimated the model including treated mothers. The estimates are similar to those in Table 3—see Online Appendix C, Table C.4a, column 2. As discussed in Section 4, while the elicited beliefs data are on average of high quality, some women report negative expected returns. We assess robustness of our results to how we treat these answers, see Online Appendix C, Table C.4a. The estimates are not sensitive to this.

We elicited expectations in pregnancy to avoid feedback effects from behaviour to reported expectations. We now consider whether mothers who already have a child behave differently on account of learning. We already showed that they do not report significantly different expectations. Re-estimating the model on first-time mothers produces similar estimates (Online Appendix C, Table C.4b, columns 2–3).

7.4. *Weights and Inference*

We show that removing weights does not substantially modify the results (Online Appendix C, Table C.4b, column 4). Our inference is unchanged if we use wild bootstrapped standard errors (Online Appendix C, Table C.4b, column 5).

7.5. *Measurement Error in Beliefs and Alternative Definition of Play*

Beliefs may be measured with error because child development in any one domain is hard to capture with one milestone. The results are similar to those for the 'end point' measure,

Table 6. *Policy Simulations.*

	(0) Baseline predicted	(1) Increase bf returns	(2) Increase pl returns	(3) Playing not costly	(4) Increase all returns + (3)	(5) Treat depression
Pr(no-bf, no-pl)	36.6	34.9	35.8	34.5	32.5	34.9
Pr(bf, no-pl)	32.0	33.9	31.3	30.2	31.5	31.2
Pr(no-bf, pl)	14.3	13.7	15.1	16.0	16.3	14.8
Pr(bf, pl)	17.1	17.5	17.7	19.3	19.6	19.1
Pr(bf)	49.1	51.4	49.0	49.5	51.1	50.3
Pr(pl)	31.4	31.2	32.9	35.3	36.0	33.9
Change Pr(no-bf, no-pl)	**0.0**	**−1.7**	**−0.7**	**−2.0**	**−4.0**	**−1.6**
Change Pr(bf)	**0.0**	**2.2**	**−0.1**	**0.4**	**2.0**	**1.1**
Change Pr(pl)	**0.0**	**−0.2**	**1.4**	**3.8**	**4.5**	**2.5**

Notes: Predicted probabilities estimated after a multinomial logit model where the preference parameters for children's developmental outcomes are evaluated jointly and where mother's alternatives are: no-bf, no-pl = not breastfeeding and not playing; bf, no-pl = breastfeeding, but not playing; no-bf, pl = not breastfeeding, but playing; bf, pl = breastfeeding and playing. Column 0—baseline predicted probabilities; column 1—the probability of children achieving developmental outcomes if the mother exclusively breastfeeds is increased by 40% of a standard deviation of the expected return from breastfeeding (14 p.p. on average); column 2—the probability of children achieving developmental outcomes if the mother plays frequently is increased by 40% of a standard deviation of the expected return from playing (13 p.p. on average); column 3—the effort cost of playing is suppressed; column 4—combines column 1, column 2 and column 3. Column 5—depression status is changed to not depressed, and beliefs and costs are set at the value that not depressed mothers have.

learning well at school, if we average over all elicited beliefs to capture beliefs over returns for a single underlying scalar of human capital (Online Appendix C, Table C.4a). We also demonstrate that the results are similar if we use two alternative measures of playing with the child (Online Appendix C, Table C.5).

7.6. *Community Norms*

Subjective expectations of returns and effort costs may respond to social norms, and our questions eliciting returns were framed in terms of what the returns for a generic woman in the community would be. Since women living in close-knit communities may also have similar investment behaviours, we may be concerned that a spatial correlation in beliefs and investments might generate the results in Table 3 even if women did not act on their beliefs. To investigate this, we analysed the variation in beliefs, costs, and investments between and within villages, see Online Appendix C, Figure C.1. We see a lot of within-village variation, which assuages this concern.

8. Policy Experiments

We use the estimated preference parameters to simulate the behavioural responses of mothers to a series of policy interventions targeted at increasing breastfeeding and stimulation during early life. These include manipulation of expected returns, effort costs, and depression status. The simulations assume full compliance (e.g., all women fully revise their expectations, or they all recover from depression). The results therefore constitute upper bounds of policy treatment effects. The estimates are presented in Table 6. Column 0 shows the baseline distributions of investments predicted by the multinomial logit model (Table 3, column 10) before any of the policies is introduced.

We first discuss the impact of **information interventions** on the benefits of breastfeeding and play. These interventions can be thought of as delivering information about the objective production function in (2), in particular about μ_2 which captures maternal efficiency in producing child human capital. Consequently, the subjective production function in (3) is revised, specifically with regards to $\eta_{2,i}$. We discuss in Online Appendix D the assumptions and methodology used to recover the individual-specific $\eta_{2,i}$ for conducting these counterfactual analyses. Armed with the $\eta_{2,i}$, we can then evaluate how changes in $\eta_{2,i}$ would change subjective expected returns and, in turn, maternal investments. An alternative approach would be to conduct the policy simulations by changing the expected returns directly. This requires fewer assumptions, but is conceptually less appealing because the subjective expected returns are not structural parameters.[32]

We benchmark the information intervention against the change in beliefs achieved in previous interventions. Looking at parenting intervention entailing between 9 and 17 sessions, there is an improvement in parental knowledge by 0.4 SD in Jamaica (Chang *et al.*, 2015), 0.49 SD in Bangladesh (Aboud *et al.*, 2013), 0.32 SD in China (Sylvia *et al.*, 2020) and 0.36 SD in Uganda (Singla *et al.*, 2015).[33]

For our policy simulations, we thus consider interventions that lead to an increase in expected returns of 0.40 of an SD, which corresponds to a 14 p.p. increase. This increase is achieved by raising $\eta_{2,i}$ by 1.1 SD.

We estimate that providing information on the expected return to breastfeeding raises the predicted probability of breastfeeding by 2.2 p.p. (4.6% of baseline) while decreasing the probability of making neither investment by 1.7 p.p. (4.5%) (column 1). Information on the expected return to playing increases the probability of playing by 1.4 p.p. (4.5%) (column 2). Overall, it seems that a fairly large increase in expected returns is required to obtain a large increase in investment.

We next simulate results of **eliminating effort costs of playing** (column 3). This affects the 36% of mothers who report that playing is tiring. We notionally ascribe this to creation of a mother group or playgroup in the community, where effort and anxiety is shared and mothers feel supported. This is associated with an increase of 3.8 p.p. (12.2% of baseline) in the predicted probability of play, and a corresponding reduction in the probability of making neither investment of 2 p.p. (5.5%).

When we combine the two information interventions with alleviating effort costs (column 4), the predicted probability of playing increases by 4.5 p.p. (14.4%). This combined intervention is also effective at reducing gaps in investment across groups. It reduces by about half the gaps in playing by education, wealth and depression status of mothers (Online Appendix D, Table D.1a). Among women who say they expect to find breastfeeding or playing costly most of the time, the combined intervention increases play by as much as 10.6 p.p. or 44.9% of the baseline (Online Appendix D, Table D.1b, panel D).

[32] Online Appendix D, Table D.3, presents the results of policy simulations conducted using this simplified approach. The findings are qualitatively similar.

[33] The intervention in Chang *et al.* (2015) used short films covering topics such as comforting, talking to children, using bath time to play and learn, and simple toys to make. The films depicted mothers exhibiting the behaviours the researchers aimed to promote. The intervention in Aboud *et al.* (2013) used a combined approach of group meetings and home visits. The programme focused on delivering key messages and providing illustrative cards on essential areas like hygiene, play, communication, gentle discipline, and healthy food choices. The programme evaluated in Sylvia *et al.* (2020) involved weekly home visits by trained personnel for six months. This curriculum aimed to stimulate child development and covered cognitive, language, socio-emotional, and motor skills through age-appropriate activities. Parents received new activities every two weeks. The intervention in Singla *et al.* (2015) involved fortnightly group sessions delivered by community volunteers, addressing five core messages (play, talking with children, healthy diet, hygiene, and fostering a loving and respectful environment). It used interactive activities to encourage parents to learn and practice new skills.

The next simulation investigates impacts of an intervention that **treats maternal depression**, which affects 30% of the sample (column 5). We posit that treated women are affected in three ways: the covariate indicating depression is set to zero, their expected costs are set to the average cost of non-depressed mothers, and their expected returns are set to the average returns reported by non-depressed mothers. This is associated with an increase of 1.1 p.p. (2.2% of baseline) in breastfeeding and of 2.5 p.p. (7.9%) in playing. In the subsample of depressed mothers, treating depression has, as we may expect, larger effects: an increase of 3.7 p.p. (7.9% of baseline in this sample) in breastfeeding and 8.2 p.p. (34.6%) in playing (Online Appendix D, Table D.1a, panel A, column 5). Treating depression is the policy with the largest effects in this subsample, where investments are low at baseline. This is consistent with the results in Baranov *et al.* (2020), who find that mothers treated for depression make larger time-intensive and monetary investments in children as long as seven years after the end of the intervention.

9. Conclusions

Millions of children do not achieve their development potential. The factors we study—inadequate nutrition, lack of early stimulation and exposure to stress—have been identified as among the most important reasons.[34]

Although the problem is now widely acknowledged, the role of maternal investment choices and the possibility that they are conditioned by maternal poverty and depression has received relatively limited scrutiny. Low levels of maternal investment in children may be driven by weak preferences for child development outcomes, low expectations for returns to investments, or by financial and psychic resource constraints. We find limited heterogeneity in preferences, but that subjective expectations of both returns to and effort costs play a significant role in explaining mother's investments in newborns.

We provide the first results showing that perceived cost of effort among mothers constrains their investment in breastfeeding and play. Moreover, we identify one important descriptive predictor of perceived costs among mothers of newborns, which is perinatal depression. Our results are embedded within a more general model of maternal investments that allows for biased beliefs over the technology of skill formation, and for differences in beliefs by socio-economic status. Simulation exercises suggest that policies aimed at increasing the mother's beliefs about returns and alleviating her effort costs can substantially raise average investment levels. We consider intervening with information on returns, creating mothers groups, or treating postnatal depression. Future research is needed to more clearly identify how to move expected returns and effort costs.

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Additional Supporting Information may be found in the online version of this article:

Online Appendix
Replication Package

[34] See https://www.worldbank.org/en/programs/earlyyears. On this same page, the World Bank reports its estimate that globally, a child born today would only reach 56% of their full adult productivity due to the risks of poor health and education.

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