Breastfeeding duration and Child Development: evidence from a natural experiment

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Abstract

Breastfeeding is widely acknowledged as beneficial for both mother and child, yet empirical evidence establishing causal links remains limited. This study investigates the causal relationship between breastfeeding duration and subsequent child development outcomes, leveraging the timing of a major earthquake in Chile as an exogenous shock. Results indicate that proximity to the earthquake event negatively affects breastfeeding duration, with each additional week away associated with an increase in 1.5 days of extra breastfeeding. Employing this exogenous variation as an instrument, a two-stage least squares (2SLS) model reveals significant positive effects on child cognitive development indicators measured two years after the event, corresponding to approximately 0.035 standard deviations per additional month of breastfeeding. In turn, the impacts on cognitive domains seven years after show a positive point estimate that is not statistically significant. However, no statistically significant impacts are observed on non-cognitive and health outcomes during this timeframe. These results are consistent with controlled trial findings. Notably, analyses of maternal outcomes yield null effects across dimensions considered, including attachment quality and employment likelihood two and seven years post-quake, suggesting that the observed effects stem primarily from neural formation mechanisms rather than mother-child interaction channels. These findings carry significant implications for public policy, suggesting the efficacy of early breastfeeding promotion interventions in fostering child development.

Keywords: breastfeeding; children development; human capital accumulation; instrumental variables

JEL Codes: I20; I24; I25; J24; I15; O12.

1 Introduction

It is widely acknowledged that investing in early childhood human capital during the first 1,000 days of life can have lasting benefits. One of the most significant investments a mother can make during this period is to breastfeed for an extended duration. Since 2003, the World Health Organization (WHO) has advocated exclusive breastfeeding for infants during their first 6 months, followed by continued breastfeeding up to 2 years. These recommendations have prompted changes in policy, including efforts to extend maternity postnatal periods, enact regulations that support breastfeeding in the workplace, and impose limitations on the marketing of products that may hinder breastfeeding, such as pacifiers or infant formula.

Breastfeeding requires significant maternal effort, favorable health conditions, and supportive environments to maintain. Despite widespread recognition of the importance of extended breastfeeding and the emphasis on prioritizing maternal lactation over supplemental formulas, evidenced by numerous policies aimed at incentivizing and protecting this practice, empirical evidence regarding the specific benefits of each additional month of breastfeeding is still lacking.

This paper aims to fill this gap, starting from an interesting observation; cohorts born closest to a major earthquake tend to have worse breastfeeding outcomes in terms of duration. Given that the timing of an earthquake is unpredictable, we propose a Two-Stage Least Squares (2SLS) approach to address potential endogeneity issues and assess the impact of extending breastfeeding duration. We use the distance in days from the earthquake as an instrumental variable to predict breastfeeding duration. Our analysis includes the full joint distribution of breastfeeding outcomes along with cognitive and non-cognitive outcomes observed two years and seven years after the earthquake. We focus our sample on children born before the earthquake and under the age of two. We support this choice because it is the ideal target suggested by WHO as a policy and because it is in this period that children are most likely to be breastfed. In particular, we exclude children who have not been breastfed ever, as they would not be affected by the mechanism under study. Our premise is based on the understanding that successful breastfeeding depends on maternal attention and normal hormonal processes essential for milk production, which may be disrupted by external stressors triggered by the earthquake. Once milk production has been disrupted by such factors, restoring it to previous levels becomes a challenge. Considering that earthquakes occur early in the lactation process, we anticipate a negative impact on the expected lactation profile, with the degree of impact varying depending on the proximity to the event.

We find that an extra month affects cognitive domains in substantial and relevant ways, with long-lasting effects even seven years later. An extra month is associated with improvements in the index we construct after Anderson (2008) for the cognitive ability screening tools available in 0.035 standard deviations (SD) two years after and 0.012 SD seven years after (but not statistically significant). These results are robust to mediation analyses including magnitude and geographic exposure to the earthquake, and to different specifications including age fixed effects or non-linear relationships to the instrument.

Our setting is particularly interesting for conducting these analyses. Ideally, we would randomly manipulate the duration of breastfeeding for each child. However, ethical constraints prevent such a manipulation. Instead, we exploit the correlation between exposure to the earthquake-induced stress event and breastfeeding patterns. Because children are affected across the entire distribution of months of duration, we can predict the marginal impact of an additional month of breastfeeding, unlike other analyses that base their results on discrete interventions that manipulate the distribution in shifts toward three, six, or even an additional year of breastfeeding. We show that our proposed instrumental variable is quasi-random based on observable characteristics. Moreover, we establish the relevance of the first stage and argue convincingly for the likelihood that the exclusion restriction holds within the time frame of our study. Our confidence in this assertion is bolstered by zero-first-stage analyses for children who were never breastfed, which reveal the expected null effects of the instrument on our target outcomes and also show null effects for children who completed their breastfeeding process just before the earthquake. In addition, using reduced-form analyses, we show that our instrument primarily affects outcomes through the breastfeeding channel, contrary to initial expectations that non-cognitive outcomes would be more strongly affected by exposure to stressors. [1] We provide insight into why this exclusion restriction holds by highlighting the resilience and quality of Chile's infrastructure, which enabled the country to withstand one of the most severe earthquakes in recent history with minimal human casualties (for more details, see Berthelon et al. (2021)).

This paper contributes to several strands of existing literature. Firstly, it adds to research exploring the effects of breastfeeding on later child development(Colaizy et al., 2024; Del Bono and Rabe, 2012; Belfield and Kelly, 2012; Baker and Milligan, 2008; Der et al., 2006). Of particular relevance to our approach is the work of Fitzsimons and Vera-Hernández (2022) , which uses the day of the week a non-c-section child is born as an instrument. This approach rests on the assumption that the day of the week is essentially random for vaginal deliveries, and babies born closest to the weekend may receive less breastfeeding support due to reduced staffing. Their findings reveal significant and enduring cognitive improvements, especially among women from poorer households. Additionally, studies examining the Promotion of Breastfeeding Intervention Trial (PROBIT) intervention in Belarus in the late 1990s are pertinent. This randomized controlled trial implemented the WHO Baby Friendly Hospital Initiative, offering healthcare worker assistance for initiating and sustaining breastfeeding. The intervention demonstrated significant and enduring effects, particularly in the cognitive domain (Kramer et al., 2008a). Our contribution lies in introducing a novel empirical approach that leverages timing variations in response to a significant stressor to assess the effects of an additional month of breastfeeding on both cognitive and non-cognitive indicators. Estimating the impact of this marginal increase in breastfeeding duration is valuable for policy analysis, as it offers a critical outcome for cost-benefit assessments, particularly within the scope of margins that can be influenced by feasible interventions.

[1] Experiencing massive earthquakes increases the propensity to develop mental and behavioral disorders by directly inducing fear or causing post-traumatic stress disorder (PTSD) (Galea et al., 2005)

Second, it contributes to the literature studying effective early child interventions, and particularly on what extent is breastfeeding an interesting target. On top of the available literature showing the impact of cash transfers (Milligan and Stabile, 2011), safety nets (Hoynes et al., 2016; Boudreaux et al., 2016), early interventions (Bharadwaj et al., 2013) or *in-utero* interventions improving nutritional intake (Field et al., 2009), this paper shows that breastfeeding promotion could be a very cost-effective intervention through hospital best practices and parent counseling

Finally, it contributes to the literature that studies how stress shocks can affect human capital accumulation (Almond et al., 2018; Currie and Almond, 2011; Cunha et al., 2010; Cunha and Heckman, 2007). Its main contribution to this strand is to highlight the role of breastfeeding as an investment that can be compromised by stressful situations with long-lasting consequences for the child.

The paper continues as follows. Section 2 describes the data and the empirical strategy, also describing some important stylized facts and mechanism that are necessary to fully understand our approach. Section 3 exposes the results and provides the discussion. And finally 4 concludes.

2 Data and Empirical Strategy

This study uses the Longitudinal Survey of Early Childhood (ELPI, acronym in Spanish), a freely accessible resource. ELPI enables the characterization and analysis of the development of consecutive cohorts from a nationally representative sample of children, taking into account household and immediate environmental factors. Additionally, ELPI facilitates the assessment of children's developmental levels by utilizing an individual-level panel, encompassing a comprehensive set of tests covering cognitive and non-cognitive domains, tracking their progression over time. Conducted in three rounds (2010, 2012, and 2017), ELPI involves updates with representative samples of the national population of children born during the intervening years. The dataset encompasses information on approximately 25,000 surveyed children, with a complete panel consisting of around 9,000 children, offering valuable insights into the developmental trajectories of the studied cohorts. Figure A1 in the appendix shows the relevant timeline of the different waves of the survey.

In February 2010, a powerful earthquake struck in central Chile, directly affecting around 80% of the population. Although material damage and loss of life were limited compared to the magnitude –an aspect explained by the country's seismic tradition and resilient infrastructure (see Berthelon et al. (2021) for an extended discussion)–, stress levels increased significantly during the period. This provides a credible source of exogenous stress variation, which we will use to correct for endogeneity in breastfeeding duration through the use of instrumental variables. Table A3 in the appendix provides evidence about the mild effects in economic activity, household quality and infrastructure.

The ELPI allows to test the impact of the stress induced by the earthquake on breastfeeding profiles, and using this, assess the impact of an extra months of breastfeeding on subsequent developmental indicators. ELPI follows a panel of children, including till now, three waves; 2010, 2012 and 2017. Wave 2012 includes specific questions associated with the earthquake, such as municipality of residence at that time and the intensity of self-reported stressors triggered by this natural event. Considering the birth date information and the time of the event it is possible to built an instrument as distance in days to the earthquake. It is highly likely that children that were older when the earthquake struck show better indicators of breastfeeding than younger ones. This is because the shock would likely create the conditions that trigger the interruption of the breastfeeding process with no turning point. And, because the distance in days is totally exogenous because the time of an earthquake is unpredictable, this offers a reliable instrument to perform a two-stage analysis.

Our focus is to answer what are the effects of this exogenous source of variation in timing affected the breastfeeding process and its duration, and then, exploiting these difference, estimate the impact of the shock on later indicators – cognitive and non-cognitive– observed in 2012 and 2017. The distance in days to the shock allows us to get rid of the endogenous sources that drive breastfeeding duration, such as endogenous preferences, (attachment to work, family composition and intensity of housework) or medical health conditions, among others. These are necessary to explain the causality in breastfeeding duration on other outcomes, but are difficult to control for because of their unobservability. The unexpected earthquake in a crucial period of development allows to provide an orthogonal shock. In doing so, we aim to contribute to expanding the literature that studies the causal effects of breastfeeding behavior on child development, expanding for the existing contributions exploiting siblings as a source of identification.

Breastfeeding and development: theoretical framework

Following the framework proposed in Fitzsimons and Vera-Hernández (2022) it is to be expected that longer duration and better quality breastfeeding will have impacts on child development through at least three channels: nutritional superiority, improvements in attachment and skin-to-skin stimulation, and income effects.

The nutritional advantage comes from the fact that maternal milk is composed by two of the crucial two long- chain polyunsaturated fatty acids that favors the development of the brain, namely, Docosahexaenoic Acid (DHA) and Arachidonic Acid (AA). In the initial year of life, infants necessitate significant amounts of DHA and AA to support brain development. They constitute essential elements of neuron membranes, integral to the nervous system, and their composition influences membrane fluidity and the activity of membrane-associated proteins like transporters, enzymes, and receptors.

In terms of attachment, breastfeeding enhances skin-to-skin contact, along with facilitating direct eye contact between the child and the mother serving as a source of stimulation. Furthermore, the production of maternal milk is linked to the release of certain hormones that may positively impact the mental health of the mother, potentially improving the quality and amount of care provided.

Finally, it is important to recognize that breastfeeding is a demanding activity that carries an opportunity cost for the mother. Opting for longer periods of exclusive breastfeeding could potentially impact the mother's future income profile, leading to a negative income shock that may also influence the child's development. There is evidence suggesting the role of hysteresis in explaining later income disparities among mothers who re-enter the labor market sooner after having a child Kuka and Shenhav (2020).

Finally, is important to note that stressful situations may affect the production of breast milk, and therefore stress may affect development through the duration and quality of breastfeeding. Medical evidence shows that the existence of stressors generates the hormonal production of cortisol. Cortisol has been associated with a poorer quality breast milk production, which contains less fat content, a fundamental element to promote brain development in early stages of child development (Ziomkiewicz et al., 2021). But not only this, the presence of stressors can affect the intensity in the frequency of lactation, which in turn affects the stimulation that makes possible the milk production process, and therefore, increasing the risk of presenting early terms in the lactation period (Kitsantas et al., 2019).

Stylized Facts

Apart of the Chilean resilient infrastructure that allows to separate the economic shock due to an earthquake with the stressor shock, there are other Chilean features that are worth to highlight because their relationship with breastfeeding outcomes.

The first of them is the high prevalence that elective c-sections have in Chile. In line with the increasing in rates of c-section all over the world, but particularly in developing countries, it is estimated that around 46% all around 200,000 birth occurring each year, where c-sections. This is way above the WHO recommendation of 15%. The driver behind this particularity would be the way these procedures are founded and the incentives this schemes generate (see Borrescio-Higa and Valdés (2019) for a review). This is an important factor to account for, because c-sections have been associated with poorer breastfeeding performance.

A second remarkable fact is that the rates of women who ever breastfed are higher than what is observed in developed countries (in our sample, only CHECK THIS 5 percent did not breastfeed), nor is the socioeconomic gradient documented in (Fitzsimons and Vera-Hernández, 2022). On the contrary, mothers from poorer strata tend to have better average duration.

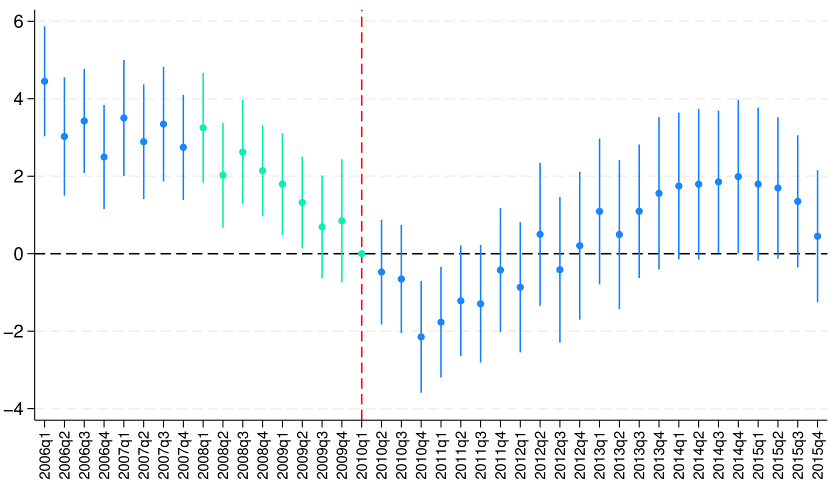
A third aspect to highlight, which perhaps helps to understand the good breastfeeding indicators, is that since 2006 there has been a universal national policy to promote good parenting practices, improve pre and perinatal controls and accompany the development of children with special tools and sub-schools up to the age of 6 years. This policy, called *Chile Crece Contigo* (ChCC), has proven to be very successful in improving both health and development indicators of the children treated (Echenique, 2021; Clarke et al., 2019).

Finally, it is worth to note that there is an important prevalence in the use of formula as a supplement. Unfortunately, due to sample restriction we do not have information about the intensive margin or about the age in which it was necessary to supplement. We do only have information about the extensive margin during the first 6 months of life and whether if it was supplemented by a pediatrician. About 48% used formula in some extent, and in 85% of those cases, it was prescribed by a pediatrician. The use of formula can negatively affect the duration of lactation, as the nipples are no longer stimulated and the necessary hormone formation process is paused. In effect, in our sample, the use of formula is associated with a decrease of 8.5 months in the total duration for those mother that have ever breastfed. This effect is a bit smaller, a 4.6 months decrease, if we estimate the impact on those mother that adopted the formula without the pediatrician's prescription.

Motivating Evidence

Our investigation is driven by the remarkable finding that children born closer to the earthquake have significantly shorter breastfeeding durations. As shown in Figure 1, a decreasing trend emerges about 8 quarters before the earthquake, continues for children conceived before the earthquake, and then reverses. This trend has the remarkable feature of showing a linear behaviour up to children who were at most 2 years old when the earthquake struck, suggesting that the timing of exposure may influence the total duration of breastfeeding. The hypothesis is that infants affected during the early stages of breastfeeding experience greater disruption due to the necessary hormonal and physiological mechanisms involved in milk production and lactation. It is noteworthy that proximity affected not only the mean values exhibited for each quarter of the birth cohort, but also the distribution, as described in Figure A2 of the appendix. It can be observed that each quarter close to the earthquake shows worse breastfeeding profiles. Meanwhile, figure A3 shows a clear spike in breastfeeding cessation in the months immediately following the earthquake, suggesting that the earthquake had a direct effect on this outcome. It is worth noting that the average duration for children who stopped breastfeeding in the months of March, April and May 2010 is 19 months with a median of 18 months, and if we restrict ourselves to the time window we studied, the median is 12 months and the average is 13.4 months.

Figure 1: Estimated Coefficients for Quarterly Fixed-Effects on Breastfeeding Duration



Note: This figure plots the estimated coefficients for the specific quarter fixed effect when regressing duration of breastfeeding against quarter of birth. Point estimates colored in green correspond to the cohort of children who were likely more exposed to the earthquake because they were breastfed. The sample includes 19,508 observations. The green dots represent children born 2 years before the earthquake who were most likely to be breastfed. This is our analysis window. The baseline corresponds to the first quarter of 2010, the quarter of the earthquake. Point estimates are shown with their 95% confidence intervals. Standard errors are clustered at the municipality level.

Adding evidence on this by regressing breastfeeding duration in total months with a set of controls and fixed effects yields the results shown in table A1 in the appendix. This is the first stage in the 2SLS approach that we will follow. The table separates the estimation according to the age of the children, dividing them into two groups: those who were born but less than 2 years old and those who were older and therefore less likely to be affected. It can be seen that an additional day before the earthquake statistically significantly improves the total duration of breastfeeding, but only for children who were less than two years old. In fact, each additional week before the quake is associated with an improvement in breastfeeding duration of about 1.5 additional days. On the other hand, for those who were older and therefore almost not exposed to the causal effect we are testing, the effect is zero. Another interesting pattern worth noting is that the coefficient of the effect almost does not change when we include controls or a set of fixed effects, reinforcing the idea of orthogonality of the instrument that we will exploit.

Finally, table A2 in the appendix shows that when the affected children are divided into two groups, one composed of those who were at most 6 months old at the time of the quake and one composed of those who were between 6 months and 2 years old, the comparisons show no significant differences in terms of the control variable, but significant differences in terms of some of the outcomes. In particular, children born closer to the date of the earthquake show worse performance on the measure of cognitive domains in 2012 (although both groups show a negative impact) and a significantly shorter duration of breastfeeding.

Empirical Strategy

We will focus our attention on those children who were already born at the time of the earthquake and who were breastfed at least once, the rationale being to avoid contaminating the estimates by including children who may have been affected by the earthquake in other ways *in-utero* (e.g. through increased rates of caesarean section or preterm birth).[2] Also because it makes the interpretation of strategy IV more intuitive: we want to include children who were affected in their breastfeeding profiles because of the more intense exposure to the earthquake, and not contaminate the estimates with facts that were already realized and are rather due to preference or health reasons.[3]

Based on the information reported by each primary caregiver in ELPI, we create the following variables. First, $Duration_i$, which corresponds to the total duration in months of the last breastfeeding. This information is self-reported by the mothers to the enumerators. If the caregiver reports still breastfeeding, this measure is imputed as the child's age in months. Second, the variable $days-to-quake_i$, which is based on the absolute distance in days between the date of birth and the date of the earthquake. To reduce the risk of measurement error due to recall bias, we impute the report closest to birth. [4]

This dataset will be used to assess the long-term effects of breastfeeding on various health and developmental outcomes. We have a wide range of instruments that we can test on different dimensions: verbal, mathematical, social-emotional, motor, etc. In order to avoid problems of multiple inference (i.e.: rejecting the null only because we are testing multiple hypotheses in the same data set), for each year of observation we construct summary indices for each of the domains: cognitive and non-cognitive for each of the ELPI follow-up waves, according to the methodology proposed in Anderson (2008).

Taking these aspects in consideration, we propose a 2SLS approach, where the first stage is defined as:

$$Duration_i = \alpha + \alpha_1 \cdot daystoquake_i + \alpha_2 \cdot \mathbf{X}_i^{'} + \gamma_m + \tau_s + \varrho_d + \varepsilon_{im} \tag{1}$$

Where, in addition to the previously defined variables, $\mathbf{X}_i^{'}$ is a vector of controls including some characteristics of the mother such as education, single status, mental health history, BFI, WAIS, income quintile, age at birth and age at birth squared, rural and ethnicity indicators, among others, and the sex of the child. Importantly, this vector $\mathbf{X}_i^{'}$ also includes the age at the time of the specific observation. This is crucial to avoid age (i.e. the older the better the cognitive performance,

[2] For a general review, see Almond and Currie (2011). For the particular case of 27-F earthquake stress on cognitive development, see Berthelon et al. (2021).

[3] In fact, if we look at the relationship between days-to-quake, our instrumental variable, and the probability of ever having been breastfed, we see that the effect is zero. The same is true when we look at the effect of being breastfed on later outcomes of interest.

[4] Li et al. (2005) show that maternal recall of breastfeeding initiation and duration, especially when obtained within 3 years of birth, provides an accurate measure of actual events.

ceteris paribus) driving the results rather than our instrument. While γ_c, τ_s and ϱ_d correspond to municipality, season and day of week of birth, [5] fixed effects. ε_i is the standard error term clustered at the municipality level. This is done to account for possible geographical correlation patterns. It is noteworthy that, as documented in Berthelon et al. (2021), the stress caused by the earthquake affected the whole country, possibly due to concern for relatives or friends in the affected zone, which covers about 70% of the population. The advantage of the dataset lies in its ability to control for relevant individual-level variables, such as mental health history or BFI characteristics, which may elicit different stress responses to the earthquake.

While, in the second stage we use the estimated effect in duration to assess the causal impact over the different outcomes of interest, $y_{i,t}$ at individual level observed in year t;

$$y_{i,t} = \beta + \beta_1 \cdot \widehat{Duration}_i + \beta_2 \cdot \mathbf{X}_i^{'} + \kappa_m + \pi_s + \psi_d + \epsilon_{im} \tag{2}$$

The final sample includes 5,672 children who were conceived between 27 February 2008 and 26 February 2010 and who were breastfed at least some of the time. The average duration for the whole sample is 15.6 months. It should be noted that 4.9% of this sample are currently breastfeeding at the time of the ELPI 2012 fieldwork. For them, the imputed duration value is the age in months at that time. The average corresponds to a duration of 39.4 months.

The identifying assumption assumes that the distance in days to the earthquake produces an orthogonal and relevant shock on breastfeeding behavior that can have long-lasting consequences and that are no other ways in which this distance measures affects the outcomes of interest. Note that other alternative effects that could affect later developmental child indicators – such as impacts on economic activities, health care facilities, unemployment, etc [6]– affected the entire sample considered, the only difference is when they were affected by this stressor. In fact, this is something that can be observed, at least for outcomes in medium run, in the Table A2. Therefore, since the timing of birth is not controlled in a country where both zones and time of the earthquake are unpredictable, it is plausible to maintain that this variation in breastfeeding behavior is indeed exogenous and instrumenting by timing provides a reliable way to estimate the impact of breastfeeding on outcomes of interest.

A threat to our identification strategy would be that during the 2-year window we consider, a stress shock may have a more detrimental effect on younger children than others for reasons unrelated to breastfeeding quality. For example, stress may programme certain developmental

[5] Fitzsimons and Vera-Hernández (2022) shows that the day of week of birth is relevant in explaining the breastfeeding indicators. The mechanism is that infants born closer to the weekend have fewer hospital staff available to teach new mothers how to properly attach the baby to the breast.

[6] Note that Berthelon et al. (2021) provide evidence using CASEN survey that these dimensions were not significantly affected by the earthquake thanks to the long resilient Chilean regulation for building and the agile reconstruction that the government led at that time. For example, a month and a half before this earthquake, Haiti was hit by a 7 MW earthquake with an epicenter in Port-au-Prince. 27-F released 178 times more energy, but the consequences are not comparable. In Haiti, more than 300,000 people died and about 1.5 million people were left homeless.There was also significant damage to critical infrastructure such as hospitals, schools, and police units.

factors that are expressed later, affecting developmental indicators. We believe that this is not a significant threat because the time window is narrow and consistent with the literature, which suggests that everything that happens within the first 1,000 days is relevant. Furthermore, if this is the case, we believe that these programmed effects are more likely to be expressed in non-cognitive and health domains, for which we do not find significant effects.

A potential challenge to our identification strategy is the risk of social desirability bias, wherein mothers might tend to overstate the duration of breastfeeding (Colen and Ramey, 2014). We believe that such a bias would probably result in underestimating the positive impact of breastfeeding on child outcomes, which, for our purposes, is not a critical concern. On the other hand, this sample offers the advantage of not being affected by the extension in the policy of parental leave in mid-2012, a change that improved breastfeeding outcomes (Albagli and Rau, 2019).

Independence Condition. Table A4 in the appendix shows that there is no control variable that is predicted by the $daystoquake_i$. If there were a way other than the breastfeeding channel in which it was impacting cognitive development, one would expect it to correlate with variables that do correlate with development such as income, the mother's level of intelligence, her education or her BFI, among others. However, in none of these are statistically significant correlations found.

Exclusion Restriction. There is no formal test to support the exclusion restriction. Formally we would want to provide evidence that variation in $daystoquake_i$ only affects child development in the three dimension considered through breastfeeding and not directly. Instead, we offer the following set of evidence that makes us think that it holds.

After Altonji et al. (2005) we check the zero first-stage test. The intuition is that in a subsample for which the first stage is zero, the reduced form should also be zero if the exclusion restriction is satisfied. We will focus on two of these groups. The first is those children who were never breastfed, and the second is those who were between 2 and 3 years old at the time of the earthquake and for whom, as shown in table A1, the first stage is not statistically different from zero. Tables A5 and A6 show the results for the reduced form. It can be seen that there is no strong relationship between our measure of distance in days and any of the outcomes of interest, except for the cognitive outcome parameter. Finally, the reduced form estimates are presented in table A7. It can be observed that the variable $daystoquake_i$ only affects our outcomes of interest in the cognitive domains. This is the same pattern that we observe when using the 2LS approach, reinforcing the idea that the only effect is through changes in the breastfeeding duration profiles.

3 Results

Effects on Children Development

Table 1 shows the estimate for each of the six composite indices considered in the two waves available.[7] First, note that the KP F statistic is above the rule of thumb of 10, which reinforces

[7]We also tested the effects on cognitive and non-cognitive measures administered in 2010. Null effects are found for both. This may be due to lack of power (the F-statistic is close to 10) or to the fact that the measurements were

the idea that the instrument we propose is relevant. The inference was made after Lee et al. (2022) to account for possible problems of weak instruments, because although our KP-F statistics are well above the rule of thumb, they are not above some other demanding thresholds proposed in the recent literature (see Andrews et al. (2019) for a review). It can be seen that after this adjustment of the confidence intervals, none of the estimates are statistically significant at the 5% level. Table A8 shows that all the relevant coefficients are not statistically significant using an OLS approach, with point estimates that are not statistically different from zero.

Table 1: 2SLS Estimations for Children Outcomes- Cohort 0-2 years old

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
Extra 1-month	0.1039**	-0.0437	0.0410	-0.1033**
	(0.0507)	(0.0434)	(0.0281)	(0.0480)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	11.60	12.04	10.30	11.00
Obs.	4,455	4,489	3,063	3,082

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

However, based on the information in Figure A3, a finer analysis can be carried out. The idea of an instrumental variable is to capture the impact on those whose outcome was affected by the instrument. Therefore, it does not make sense to include those children who had already stopped breastfeeding for other reasons before the date of the earthquake, so we split the analysis in two; firstly, those children within the cohort of interest who stopped breastfeeding after the earthquake and were therefore directly affected, and secondly, those children within the cohort who stopped breastfeeding before the earthquake and were therefore not affected. We expect to find null effects in this group, while we expect the largest effects in the first group.

Table 2 shows the results for the effect of an additional month of breastfeeding on the outcomes of interest. Notably, despite the children being from the same cohort and having a decent first stage of power, we did not find a statistically significant effect at the 5% level. Table 3 shows the results when considering the children in the cohort who stopped breastfeeding after the earthquake. Statistically significant results are observed for cognitive development of 0.035 standard deviations observed in 2012, two years later, and for negative health effects of 0.034 standard deviations observed two years later. In terms of indicators in 2017, it is observed that an additional month of breastfeeding is associated with a decrease in non-cognitive indicators 7 years after the earthquake, but this coefficient is not significant when making inferences as suggested in Lee et al. (2022).

taken very close to the earthquake, without enough time for the effects to mature.

Table 2: 2SLS Estimations for Children Outcomes - Children in the cohort that had already completed breastfeeding

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
Extra 1-month	0.0513*	-0.0545	0.0569*	-0.0648
	(0.0279)	(0.0355)	(0.0323)	(0.0515)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	36.14	36.55	23.52	25.75
Obs.	1,861	1,876	1,261	1,271

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: 2SLS Estimations for Children Outcomes- Children in the cohort that completed breastfeeding after 27-F

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
Extra 1-month	**0.0352***	-0.0081	0.0120	-0.0571***
	(0.0124)	(0.0134)	(0.0153)	(0.0171)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	94.94	96.08	58.01	62.47
Obs.	2,469	2,488	1,727	1,736

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

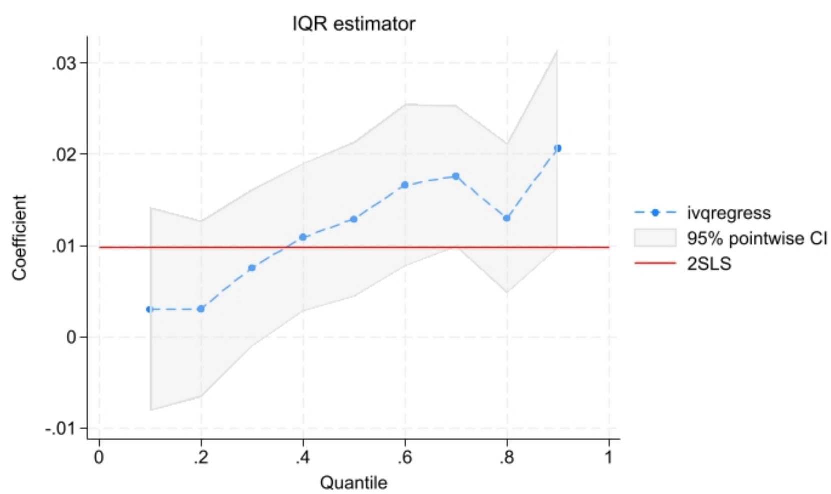
Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Interquartile Regression. An interesting extension is to examine how estimates of an additional effect on breastfeeding vary across the distribution of the cognitive12 index. Using the methodology proposed in Chernozhukov and Hansen (2006), we extend to quantile regression with instrumental variables. If there are non-constant effects in the distribution, this would generate warnings that there are factors related to the cognitive distribution, such as income level, education, initial intelligence or labour market attachment, that explain the results, or the level of investment that the mother makes in the children (related to the second factor of the theoretical mechanisms we propose). Conversely, obtaining consistent results across the distribution would suggest that the effect is more associated with biological factors that should affect the population uniformly, in line with the nutritional mechanism described above. Figure shows the estimates for each decile. The interquartile coefficients are consistent with the 2SLS estimate, suggesting that the effects are constant across the cognitive12 distribution. This is strengthened by the fact that the null hypothesis of constant effects across deciles cannot be rejected.

Figure 2: Interquartile IV regression



Note: This figure plots the interquantile coefficients when running ivqregress on the cognitive composite index measured in 2012. After 1,000 replications, the null hypothesis of non-effect is rejected, the null hypothesis of constant effects is not rejected, and the null hypothesis of duration being exogenous is rejected.

Mediation Analysis. Although evidence in favour of the exclusion restriction has been presented, there may still be doubts that the earthquake does not affect the results in ways that are not controlled by the model. To this end, we check the stability of the estimates by considering the inclusion of controls related to the earthquake, in particular a dummy associated with whether the area of residence was affected, a continuous variable indicating the intensity on the Mercalli scale, and a dummy for self-reported damage to the house due to the earthquake, where 1 is severe damage. Table A9 shows the results. It can be seen that the estimates are quite stable, even if we restrict the sample to the affected regions.

Unpacking the effects. As the inferences have been made using composite indices, it is useful to check which components drive the results.It can be observed that the significant results in cognitive12 are driven by the results in Batelle and in TVIP, with 0.05 and 0.02 standard deviations respectively. Batelle contains a single indicator that includes the result of the assessment of basic developmental skills in five areas (personal and social, adaptive, motor, communication and cognitive). The Peabody Picture Vocabulary Test is a psychometric instrument that measures a child's receptive or auditory vocabulary.

Table 4: 2SLS Estimations for Cognitive12 and Health12 elements

	Batelle	TADI Cognitive	TADI Leng	TVIP
Extra 1-month	**0.0527*****	0.0227**	-0.0072	**0.0200****
	(0.0136)	(0.0112)	(0.0127)	(0.0091)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	93.04	94.94	94.21	95.06
Obs.	2,426	2,440	2,433	2,452

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Heterogeneity Analyses

To investigate possible heterogeneous effects, we examine whether or not the coefficients change when different sample splits are applied. Based on the literature, we propose the following splits: 1) whether the residential area was affected by the earthquake, 2) whether formula feeding was required during the first six months of life, 3) the child's sex, 4) the mother's primigravida status, 5) whether the mother contributed to the formal labor system before becoming pregnant or not, 6) whether the mother is in a relationship, 7) whether the birth took place in a public hospital, and 8) whether the household belongs to a high or low SES according to the income quintile (low being those in the first and second quintiles).

Figure 3 shows each coefficient. In all of them, the levels of heterogeneity are not very relevant, although they have sufficient power. In panel (a) we can see that for cognitive 12 the highest levels of heterogeneity are in public hospitals versus clinics and in being a contributor or not before pregnancy. Both elements are associated with differences in earnings. However, this pattern is reversed when we look at the differences in the coefficients by income level (being poor, belonging to the 1st and 2nd quintiles). Interestingly, there are no significant differences in the effects based on the use of the formula. In our sample, 45% of the children received formula during the first six months of life, and the vast majority (85% of them) were prescribed by a pediatrician. This casts doubt on the harmfulness of formula feeding, which is so widespread and has been used to support policies such as bans on the marketing of pacifiers and formula.

In general, the level of heterogeneity is not very high. Evaluating these findings in the light of theory would support the idea that breastfeeding affects development more for biological-nutritional reasons than for reasons related to attachment or income effects. This is because if the effects are biological in nature, one would expect them to be rather homogeneous across different population subgroups, whereas if there is a high degree of heterogeneity, it could reinforce the idea of other channels that also interact with observable variables such as education, income, family support, or work attachment.

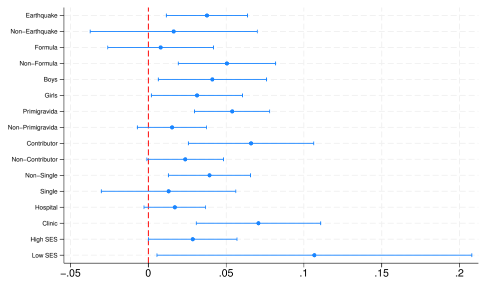
Robustness Checks

These results are robust to different specifications. Table A10 shows the estimates when we perform the same analyses but trim the duration variable, dropping those observations above the 90th percentile. In turn, table A11 shows the estimates when, instead of including age at observation, we specify a more demanding model that includes half-year age fixed effects. On the other hand, table A12 shows the estimated effects when, instead of the indicated months of duration, a category based on a 6-month period is considered. This accounts for some possible measurement error in the variable due to self-reporting. We see that the pattern of results is robust, with an additional 6 months of breastfeeding associated with a 0.21 standard deviation improvement in cognitive domains two years later. Finally, table A13 shows the results when the estimates, instead of considering only $daystoquake_i$ as the instrument, also include the square of $daystoquake_i$ as a way to account for non-linearities. It can be seen that the results are still robust to this specification, which only reduces the power of the first stage.

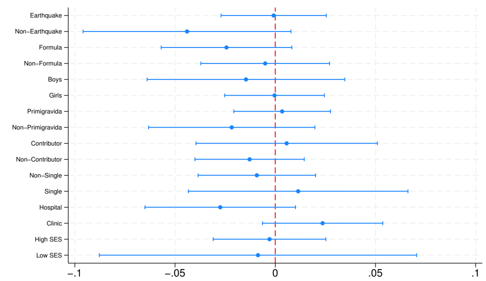
Possible Channel: Effects on Mothers Development

In order to gain some insight into the mechanisms behind these patterns, we will take advantage of the rich data available to also study the effects of an extra month of breastfeeding on a set of maternal outcomes. The assumption is that if the entry and attachment channels described above are effective, we should see effects on the mother, in direct improvements in indicators of the mother-child relationship or improvements in mental health or labor outcomes afterwards. Theory and evidence in the medical literature suggest that increased breastfeeding could have positively impacted maternal health and attachment. If evidence supporting this is found, the attachment and mother-child interaction channel would be dominant. Table 5 shows the results. Statistically significant results are only found for increases in BMI two and seven years later, in the order of an increase of 0.007 standard deviations, being irrelevant in economic terms. Although insignificant, the point estimates suggest increases in the probability of having a clinical case in PSI, a crucial indicator to measure quality in the mother's relationship with her child, in both 2012 and 2017, as well as increases in the probability of suffering from depression two years after the earthquake.

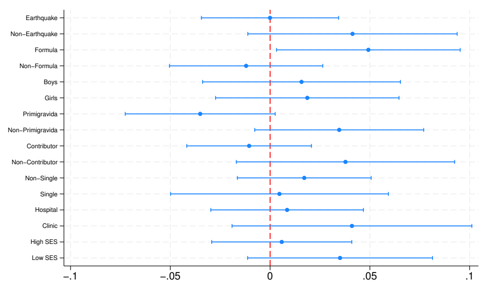
Figure 3: Heterogeneity Analysis by several sample splittings on the four Outcomes of Interest



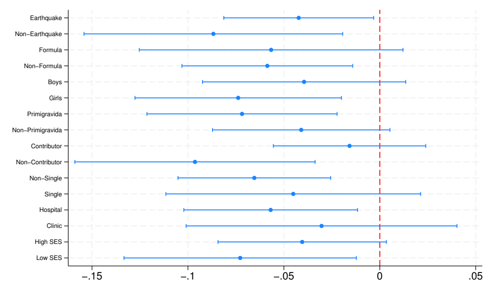
(a) Cognitive12



(b) Non Cognitive12



(c) Cognitive 17



(d) Non Cognitive 17

Note: These four panels present the estimates for heterogeneity analyses splitting the original sample (cohort aged between 0-2 year ever breastfed) according to different dimensions on the set of outcomes of interest. The regressions are still using 2SLS models following 2. Point estimates are displayed along with their 95% confidence intervals.

Table 5: 2SLS Estimation of Instrumenting Duration over mother's outcomes

	Post Dep	Dep 12	PSI 12	Preg 12	BMI12	Working 12	PSI 17	BMI 17	Working 17
Extra 1-month	-0.0003	0.0016	0.0025	0.0030	**0.0076****	0.0022	0.0010	0.0083*	-0.0017
	(0.0013)	(0.0010)	(0.0020)	(0.0019)	(0.0033)	(0.0019)	(0.0019)	(0.0044)	(0.0023)
Controls + FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KP F-stat	1408.01	1408.01	1096.91	575.79	1479.99	1408.01	773.38	710.10	881.38
Obs.	2,853	2,853	2,043	2,375	2,611	2,853	1,842	1,747	1,964

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

When we perform similar heterogeneity analyses as above, we find three maternal outcomes that show some degree of heterogeneity: 2012 BMI, 2012 depression, and 2017 BMI. The results are shown in Figure A4. It can be seen that depression in 2012 is driven by the impact on high SES mothers and non-single mothers. In turn, the increase in BMI in 2012 is driven by nonprimigravida mothers, high SES households, and noncontributors. Finally, the effects on BMI in 2017 are driven by noncontributor mothers and nonprimigravida mothers. Note that BMI is a marker of stress, which may indicate that these groups face greater difficulties in sustaining prolonged breastfeeding.

Taken together, these results weaken the notion that the attachment channel is dominant, leaving room for the possibility that the channel driving the results is that of nutritional improvements that favor neural brain development at a crucial stage.

4 Conclusion

Breastfeeding constitutes a crucial process for human development, with recommendations indicating that up to 2 years is considered ideal, although a technical consensus on the optimal duration is lacking. Attaining this length requires significant maternal effort, and without favorable material, social, and economic conditions, this endeavor may transform into a mental burden.

Despite the widespread conventional wisdom that breastfeeding is the gold standard for achieving better levels of child development, there is little evidence to support this. In this study, we propose an empirical design that exploits the time distance to a stress shock with shorter duration of breastfeeding to estimate the causal effect of breastfeeding. Unlike most of the literature that examines discrete jumps in the duration distribution (i.e., from 0 to 6 months or from 6 months to 12 months), our methodology is able to estimate a continuous effect on the intensive margin. We find a robust positive impact associated with an additional month of breastfeeding, which manifests itself only in the cognitive domain observed at 2 years, with an improvement of 0.035 standard deviation after the earthquake. This effect disappears after seven years. Null effects are found in non-cognitive domains in both periods. This estimation provides more informative insights for policy makers when assessing the trade-offs and cost-effectiveness of breastfeeding promotion proposals. The collective results suggest that the effects are driven more by the biological pathway of breastfeeding development than by what is associated with better interaction between mother and child. This underscores the irreplaceability of mothers in this crucial early investment and provides clear guidance for policy makers. It is worth noting that this "uniqueness" of mothers' investment technology becomes less relevant as available formulas have a biological composition more similar to breast milk.

Policymakers may find promoting extended breastfeeding an interesting and powerful cost-effective policy. The margins of mass-scalable and economically affordable policy interventions are unlikely to extend breastfeeding for a significant number of months. However, our research shows that even moving it for just an extra month has significant impacts on children's cognitive development, manifested 2 and 7 years later. This, combined with the literature on dynamic complementarities inherent in interventions focused on these stages, makes this type of policy highly interesting, especially for low-income groups with some attachment to the labor market.

Finally, our results are consistent with the reported positive effects of breastfeeding on cognitive indices and the absence of significant effects on non-cognitive indicators in Fitzsimons and Vera-Hernández (2022). However, there is a discrepancy regarding the improvement in attachment quality between children and their mothers, which may be due to the use of a different test or to the fact that they look at a sub-sample of mothers who come from low SES.[8]. Moreover, our findings are consistent with those in Colen and Ramey (2014), where the positive results from the naive regression, especially in the intermediate term for those who do not receive bottled milk, dissipate when family fixed effects are considered. Our results are also consistent with the only RCT evaluating the promotion of longer breastfeeding based on the Promotion of Breastfeeding Intervention Trial (PROBIT) initiative in Belarus (Kramer et al., 2009, 2008b, 2007), which finds only persistent and significant effects in cognitive domains, but not in non-cognitive domains. However, our results show that although the point estimate for cognitive 17 is positive and consistent with these findings, it is not statistically significant in our method.

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[8]In fact, if we restrict our sample to low SES women, we see that the point estimate flips the sign according to this finding

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Appendix Tables and Figures

Appendix Table A1: Days-to-quake and Breastfeeding Lenght by age at the Earthquake

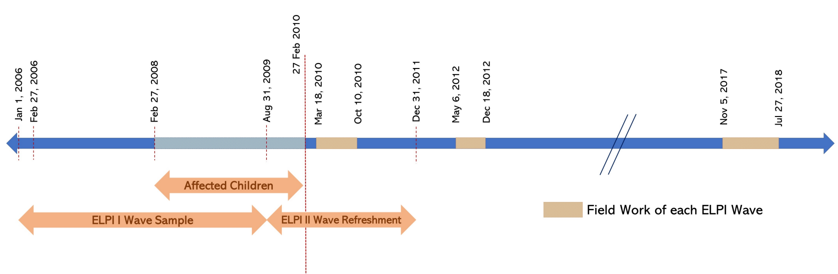
	0-2 Years Old		2-3 Years Old	
	Duration	Duration	Duration	Duration
Days-to-quake	0.0082***	0.0073***	0.0022	0.0011
	(0.0023)	(0.0023)	(0.0037)	(0.0047)
Const.	11.3659***	11.3864***	11.5701**	18.7033***
	(3.3146)	(3.3995)	(5.3013)	(6.0817)
Controls	Yes	Yes	Yes	Yes
Age Control	Yes	Yes	Yes	Yes
Comuna FE	No	Yes	No	Yes
Day of Week FE	No	Yes	No	Yes
Season FE	No	Yes	No	Yes
Obs.	4,885	4,885	2,782	2,782

Source: Author's own elaboration based on ELPI 2010-2012

Clustered Standard Errors at Municipality Level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Figure A1: ELPI field work and sampling time windows



Note: This figure describes the relationship between the date of the earthquake, the different cohorts studied in each ELPI wave, and the dates when the fieldwork of each wave was conducted. It can be seen that the affected children were more than 28 months old at the time of the Wave II fieldwork and 94 months old at the time of the Wave III fieldwork.

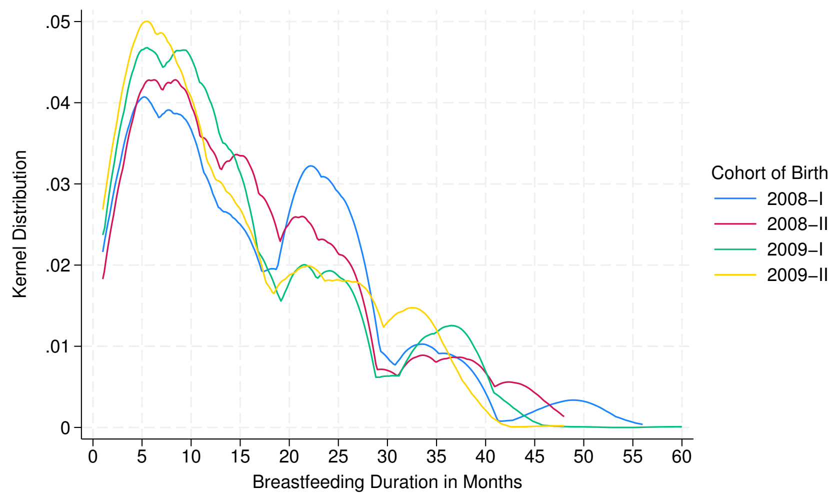
Appendix Table A2: Comparison in relevant groups

	All		0-6 Months Old		6 months-2 years		Difference
	mean	sd	mean	sd	mean	sd	diff.
Controls							
Rural	0.105	0.307	0.127	0.334	0.102	0.303	-0.025*
Edu.Mother	11.545	2.874	11.734	2.828	11.520	2.879	-0.214*
Plan Prg	0.465	0.499	0.462	0.499	0.466	0.499	0.004
Public Insurance	0.887	0.316	0.863	0.344	0.891	0.312	0.028**
Not Single	0.699	0.459	0.692	0.462	0.700	0.458	0.008
Hosp.	0.743	0.437	0.719	0.450	0.747	0.435	0.028
PAD	0.175	0.380	0.179	0.384	0.175	0.380	-0.005
# Brothers	0.874	0.990	0.957	1.041	0.862	0.982	-0.095**
Etnicity	0.084	0.278	0.085	0.279	0.084	0.278	-0.000
Boy	0.509	0.500	0.510	0.500	0.509	0.500	-0.002
WAIS	0.035	0.994	-0.164	1.050	0.059	0.984	0.223***
BFI	0.007	1.002	0.030	0.997	0.004	1.003	-0.026
Contributor	0.316	0.465	0.316	0.465	0.316	0.465	0.000
Age at birth	27.092	6.955	27.363	6.684	27.055	6.991	-0.308
Overweight	0.302	0.459	0.298	0.458	0.302	0.459	0.005
quintil	2.958	1.396	3.004	1.375	2.952	1.399	-0.053
Mental Hist.	0.140	0.347	0.126	0.332	0.142	0.349	0.016
C-sect	0.457	0.498	0.470	0.499	0.455	0.498	-0.014
Incubator	0.059	0.235	0.061	0.239	0.059	0.235	-0.002
Preterm	0.065	0.246	0.033	0.178	0.069	0.254	0.037***
birthweight	3.388	0.490	3.404	0.480	3.385	0.491	-0.018
Still BF in 2012	0.050	0.218	0.114	0.318	0.041	0.199	-0.073***
Stress Intensive Margin	0.721	1.206	0.735	1.253	0.719	1.200	-0.015
primigravida	0.436	0.496	0.405	0.491	0.440	0.496	0.035*
No Migration	0.974	0.158	0.997	0.054	0.971	0.167	-0.026***
Region Earthquake	0.763	0.425	0.775	0.418	0.762	0.426	-0.013
Outcomes							
Extra 1-month	15.646	11.003	14.270	10.414	15.832	11.068	1.562***
Cognitive 2012	-0.214	0.876	-0.314	0.767	-0.202	0.888	0.112***
Non-Cognitive 2012	-0.114	0.911	-0.065	0.925	-0.120	0.910	-0.055
Cognitive 2017	0.057	0.885	0.007	0.927	0.063	0.880	0.056
Non-Cognitive 2017	-0.011	1.008	0.029	0.982	-0.016	1.011	-0.044
Observations	5687		675		5012		5687

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

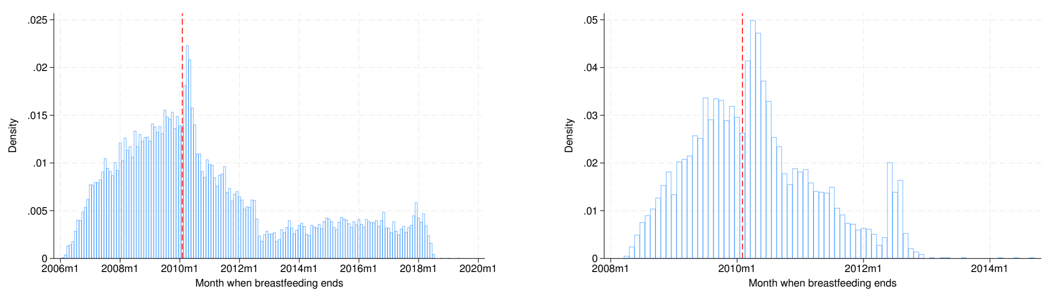
Source: Author's own elaboration based on ELPI 2010-2012

Appendix Figure A2: Estimated K-Density of total length of breastfeeding by year of birth



Note: This figure illustrates the estimated kernel density for breastfeeding duration according to the year of birth. To enhance readability, durations exceeding the 95th percentile have been winsorized. The Epanechnikov kernel with automatic bandwidth selection was employed for estimation. The dataset consists of the following birth year cohorts: 2006 (3,361 observations), 2007 (3,440 observations), 2008 (3,471 observations), 2009 (2,925 observations), and 2010 (1,350 observations)..

Appendix Figure A3: Histogram for breastfeeding ending month

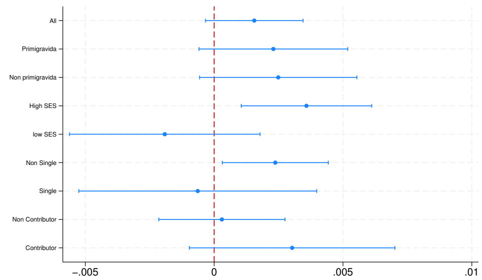


(a) Whole Sample

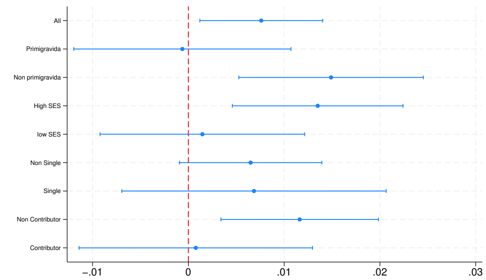
(b) 0-2 Y/O ever breastfed

Note: This figure shows the histogram of the months in which breastfeeding ended. Panel a) shows the histogram for the complete set of observations starting in Jan,2006 and finishing in Dec, 2016. Panel b) shows the histogram for our cohort of interest, children between 0 and 2 years old when the quake struck and and who were once breastfed. This variable is estimated by adding the total duration in months reported by the mother to the month of birth. A spike can be seen just after the earthquake in February 2010. Of the 5,687 children aged 0-2 years at the time of the earthquake, 42.7% (2,427) had already ceased breastfeeding at the time of the earthquake for reasons unrelated to the earthquake.

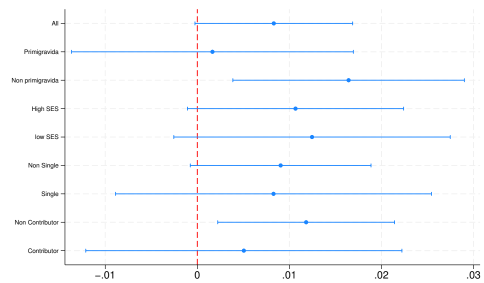
Appendix Figure A4: Heterogeneity Analyses for Mothers' Outcomes



(a) Depression 2012



(b) BMI 2012



(c) BMI 2017

Note: This figure shows point estimates for different sampling splitting on maternal outcomes.The regressions are still using 2SLS models following 2. Point estimates are displayed along with their 95% confidence intervals.

Appendix Table A3: Descriptive Statistics Before and After 2010 Earthquake (CASEN 2010).

Variables	Region Non-Earthquake 2009	Region Non-Earthquake 2010	Earthquake 2009	Earthquake 2010
Mental health/stress symptoms (Frequency)	n.a.	2.3	n.a.	6.0
Mental health/stress symptoms (Intensity)	n.a.	2.2	n.a.	5.6
Fetal Mortality (Rate/1000 born)	8.6	8.8	9.2	9.4
Living in Rural area (Fraction)	0.31	0.31	0.29	0.29
Married (Fraction)	0.32	0.32	0.37	0.37
Working (Fraction)	10.1	10.2	10.3	10.3
Working at least 1 hr. last week (Fraction)	0.69	0.70	0.69	0.67
General Health, self-reported index (1-7)	5.6	5.7	5.6	5.6
Housing Global Quality (1-3)	1.31	1.26	1.30	1.30
Outward Housing Appearance Index (1-3)	1.33	1.46	1.30	1.55
Household Income (CL $'000)	653	590	551	503

Source: Berhtelon et al. (2020)

Note: CASEN 2010 is a follow-up to asses 27-F impacts on the same individuals surveyed in CASEN 2009

Appendix Table A4: Days-to-quake and Breastfeeding Lenght

	Effect of days-to-quake on		
	Beta	SE	p-value
Rural	0.0000	0.0000	0.256
Ed. Mother	-0.0004	0.0002	0.056
Planned	0.0000	0.0000	0.756
Public Insurance	0.0000	0.0000	0.754
No single	0.0000	0.0000	0.386
Hospital	0.0000	0.0000	0.794
PAD	0.0000	0.0000	0.733
Tot Brothers	0.0001	0.0001	0.318
Ethnicity	0.0000	0.0000	0.996
Child Sex	0.0000	0.0000	0.453
WAIS	0.0001	0.0001	0.185
BFI	-0.0001	0.0001	0.401
Contributor	0.0000	0.0000	0.296
Age at Labor	0.0001	0.0004	0.823
Overweight	0.0000	0.0000	0.883
Quintile	0.0000	0.0001	0.644
Mental health	0.0000	0.0000	0.504
C-section	0.0000	0.0000	0.410
Incubator	0.0000	0.0000	0.671
Preterm	0.0000	0.0000	0.185
Birth weight	0.0000	0.0000	0.976
Still	-0.0001	0.0000	0.000
Stressors	0.0000	0.0001	0.820
Primigravida	-0.0001	0.0000	0.050

Clustered Standard Errors at Municipality Level

OLS regression with municipality, season and day-of-week FE

Source: Author's own elaboration based on ELPI 2010-2012

Appendix Table A5: Zero first-stage for Children Outcomes using children that were never breastfed

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
daystoquake	0.0007	-0.0007	0.0012	-0.0021*
	(0.0012)	(0.0010)	(0.0009)	(0.0012)
Const.	-1.2314	-1.7771	2.6001	-7.7639**
	(1.3325)	(1.2555)	(2.7639)	(3.5394)
Controls + FE	Yes	Yes	Yes	Yes
Obs.	586	594	381	386

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A6: Zero first-stage for Children Outcomes using children that were never breastfed

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
daystoquake	0.0015**	-0.0004	0.0003	-0.0009
	(0.0006)	(0.0005)	(0.0005)	(0.0006)
Const.	-0.9187	-1.7962***	-0.8668	-3.7080**
	(0.5903)	(0.6020)	(1.0246)	(1.4252)
Controls + FE	Yes	Yes	Yes	Yes
Obs.	2,559	2,570	1,824	1,826

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A7: Reduced form Estimations for Children Outcomes

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
daystoquake	0.0008***	-0.0003	0.0004	-0.0011***
	(0.0003)	(0.0004)	(0.0002)	(0.0003)
Const.	-1.0205***	-1.1792**	-0.4911	-3.3555***
	(0.3775)	(0.4620)	(0.7478)	(1.0492)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat				
Obs.	4,466	4,502	3,230	3,253

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A8: OLS Estimations for Children Outcomes- Cohort 0-2 years old

	Cognitive 12	Non Cognitive 12	Health 12	Cognitive 17
Extra 1-month	-0.0011	-0.0010	0.0001	-0.0027
	(0.0013)	(0.0013)	(0.0016)	(0.0018)
Const.	-1.6851***	-0.8952***	-1.4371***	-0.3708
	(0.3253)	(0.3098)	(0.4371)	(0.4335)
Controls + FE	Yes	Yes	Yes	Yes
Obs.				
N	4,455	4,489	3,063	3,082

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A9: 2SLS Estimations for Children Outcomes -Mediation analysis

	Cognitive 12	Cognitive 12	Non Cognitive 12	Non Cognitive 12	Cognitive 17	Cognitive 17	Non Cognitive 17	Non Cognitive 17
Extra 1-month	**0.0353*****	**0.0414*****	-0.0081	-0.0082	0.0123	-0.0139	-0.0574***	-0.0370*
	(0.0124)	(0.0138)	(0.0134)	(0.0170)	(0.0153)	(0.0175)	(0.0172)	(0.0196)
Region Earthquake	17.7321***		-9.1574**		-22.8864***		4.1603	
	(3.5197)		(3.6252)		(3.3517)		(3.8284)	
Mercalli Scale	-2.5335***	0.1081	1.2391**	-0.2972***	3.2015***	-0.5627***	-0.5167	-0.2691*
	(0.5117)	(0.1108)	(0.5208)	(0.1102)	(0.4763)	(0.1145)	(0.5446)	(0.1508)
Destroyed	-0.0524	-0.0271	-0.0835	-0.0872	0.0500	0.0498	-0.0580	-0.0484
	(0.0645)	(0.0666)	(0.0682)	(0.0716)	(0.1000)	(0.1092)	(0.1037)	(0.0991)
Controls + FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KP F-stat	94.48	56.12	95.63	57.04	57.90	32.80	62.57	36.77
Obs.	2,469	1,743	2,488	1,761	1,727	1,187	1,736	1,194

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A10: 2SLS Estimations for Children Outcomes -trimming 0-90 percentiles

	Cognitive 12	Non Cognitive 12	Health 12	Cognitive 17
Extra 1-month	0.0513***	0.0017	0.0202	-0.0396*
	(0.0170)	(0.0144)	(0.0185)	(0.0222)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	150.02	152.70	60.67	65.10
Obs.	1,963	1,976	1,351	1,358

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A11: 2SLS Estimations for Children Outcomes - Semester FE

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
Extra 1-month	**0.0277*****	-0.0033	0.0050	-0.0388***
	(0.0099)	(0.0094)	(0.0133)	(0.0117)
Controls + FE	Yes	Yes	Yes	Yes
Semester FE	Yes	Yes	Yes	Yes
KP F-stat	102.08	102.56	69.51	73.05
Obs.	2,469	2,488	1,727	1,736

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A12: 2SLS Estimations for Children Outcomes - Duration Categorized

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
6 Months-Category	**0.2134*****	-0.0491	0.0795	-0.3789***
	(0.0761)	(0.0791)	(0.1007)	(0.1154)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	193.50	198.87	49.34	52.58
Obs.	2,469	2,488	1,727	1,736

Duration is instrumented following 2

KP corresponds to Kleibergen-Paap rk Wald F statistic.

In bold those coefficients that are significant at 5% level according to Lee et al. (2022)

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A13: 2SLS Estimations for Children Outcomes -Different Functional Form

	Cognitive 12	Non Cognitive 12	Cognitive 17	Non Cognitive 17
Extra 1-month	0.0335***	-0.0087	0.0125	-0.0568***
	(0.0121)	(0.0128)	(0.0152)	(0.0170)
Controls + FE	Yes	Yes	Yes	Yes
KP F-stat	50.11	50.31	29.27	31.48
Obs.	2,469	2,488	1,727	1,736

Duration is instrumented following 2 but using *daystoquake* and $daystoquake^2$

KP corresponds to Kleibergen-Paap rk Wald F statistic.

The adjustment proposed in Lee et al. (2022) does not work in over-identified IVs

Clustered Standard Errors at the Municipality Level

Source: Author's own elaboration based on ELPI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$