The effect of Ecuador's 1998-2000 economic crisis on child health and cognitive development

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Very Preliminary, please do not cite

1 Introduction

In developing countries optimal instruments to smooth consumption such as insurance and credit are often scarce. Thus, during negative economic shocks, households respond by reducing consumption, and/or using sub optimal instruments to smooth consumption such as selling productive assets. If households are forced to reduce consumption or sacrifice nutritional quality during negative economic shocks, this can have detrimental effects on children's health and cognitive development. The impact of negative economic shocks is exacerbated if governments cannot adequately respond to the shock and instead are forced to reduce public spending. My goal is to investigate the impact of the 1998-2000 Ecuadorian crisis on children's health and cognitive outcomes.

The 1998-2000 Ecuadorian crisis was triggered by the El Niño phenomenon, a drop in oil prices, and the international financial crisis. These three events led to a banking and financial crisis within Ecuador that caused prices to increase dramatically and public spending to decrease. While many reports show that consumption fell and poverty increased during the crisis, there is little information on how children's health and cognitive outcomes were affected. From a policy perspective this is important not only because we care about child outcomes in their own right but also because worse health and cognitive outcomes early in life lead to worse education and labor outcomes later in life [Maluccio et al., 2006, Glewwe and Jacoby, 1995, Glewwe et al., 2001]. Thus, it is important to understand how children are affected during economic crises and find ways to mitigate the impact.

The possible mechanisms through which the crisis impacted a child's development are through a deterioration of the health environment (due to decreased public spending and El Niño); a reduction in the consumption of normal goods such as food, health services and early childhood stimulation; and a change in parents time spent on the care of their children. The direction of the change in parent's time is ambiguous because on the one hand a reduction in current income may lead to a reduction in the opportunity cost of time, and therefore, to parents spending more time with their children [Miller and Urdinola, 2007]. On the other hand, a reduction in current income may lead to distress work and an increase in the labor participation of secondary workers (often mothers)[Bhalotra, 2009]. While disentangling these effects is beyond the scope

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of this paper, preliminary results suggest that child health and cognitive development were not pro-cyclical thus ruling out any large increases in parental time.

The data I use to identify the impact of the crisis is health and cognitive development data for children 0-6 years old, collected by the Government of Ecuador and the World Bank in 2003 and 2005. Thus, affected children in the sample were 0-3 years old during the crisis. This timing is important because many studies show that children's physical growth and cognitive development are the most vulnerable to insults in their first two/three years of life. Any malnutrition and deficits occurring during these years will permanently affect their growth [Carter and Maluccio, 2003]. Consequently, malnutrition that may have occurred in children 0-3 years old during Ecuador's economic crisis would lead them to have worse health outcomes after the crisis. Due to the fact that health outcomes are measured three and five years after the crisis, this study provides insight on whether the impact of the economic crisis persisted.

In order to estimate the effect of the crisis on health and cognitive outcomes I take advantage of the variation in exposure to the crisis due to birth month and province. The two rounds of survey allow me to control for age using indicators and not lose variation in exposure. In other words, a 5 year old child surveyed in 2003 will have been differentially exposed to the crisis when compared to a 5 year old surveyed in 2005. In addition to age fixed effects, I use mother-fixed effect to control for the endogenous response of mothers to the crisis and I control for time trends in a linear fashion. Thus, identification of the impact of the crisis occurs by comparing sibling differences in outcomes across households with children of similar ages but who were differentially exposed to the crisis. Preliminary results suggest that one year in the crisis decreased height by 6% and cognitive development (as measured by TVIP scores) by 4%.

The contribution of this investigation to the literature is two fold. First it provides a case study on how the 1998-2000 Ecuadorian economic crisis affected early childhood development. Second, it provides general insight on how negative economic shocks affect cognitive development. While other studies have investigated the impact of economic shocks on children's health, to my knowledge, there are no other quantitative studies assessing the impact of macro-economic shocks on young children's cognitive development.

The rest of this paper is organized as follows: Section 2 reviews the literature on shocks and child outcomes; Section 3 provides background information on the crisis; Section 4 discusses the data I use to conduct my analysis and presents descriptive statistics; Section 5 presents a simple conceptual framework and the estimation problem; Section 6 discusses the econometric strategy used; Section 7 provides some preliminary results; Section 8 concludes.

2 Literature Review

Shocks and health: The evidence of the impact of shocks on children's health is mixed. As Ferreira and Schady [2009] assert, the ambiguous effect is due to the counter-acting processes of increased time and decreased private and public spending that result from negative income shocks. Their conceptual framework and review of the literature lead them to conclude that in general, health outcomes will improve during economic downturns in developed countries but will worsen during economic downturns in developing countries. The discrepancy is due to the relative importance of time versus income in developed and developing countries. Focusing mainly on developing countries, the literature review that I conduct below shows that this generalization tends to hold.

One popular instrument used to investigate how income shocks influence child health is rainfall shocks. For example, Jensen [2000] uses the Côte d'Ivoire Living Standard Surveys to compare changes in enrollment, nutritional status, and use of health services for areas affected by the rainfall shock and areas not affected. He finds that children living in regions exposed to adverse weather shocks had worse health and education outcomes than those living in non-shock areas. His identifying assumption is that in the absence of the rainfall shock, the two groups would have followed similar paths of investment in children. Hoddinott and Kinsey [2001] examine how the 1994/1995 drought in Zimbabwe affected children's growth rates. They find that the drought lowered annual growth rates for children 12-24 months by 1.5 to 2 cm, but it did not have an effect for children 24-60 months. Thus they provide evidence that children are the most vulnerable when they are 0-2 years old.

Stillman and Thomas [2008] and Carter and Maluccio [2003] use variation in household resources to explore how shocks impact an individual's health. Specifically, Stillman and Thomas use a household's per capita expenditure to investigate how Russia's 1996-1998 economic crisis impacted a household's nutritional status. They make the distinction of short-term and long term variation, and find that nutritional status is resilient to short term fluctuations but not to long term fluctuations. Their detailed data allow them to not only analyze many nutritional outcomes (energy intake, adult's BMI, and child height and weight) but to also explore how a household's food expenditure shifted during the crisis. They find that it shifted towards foods with declining relative prices and with more calories per quantity purchased. Carter and Maluccio examine the effects of shocks on children's nutritional status in South Africa by using the self reported measures of losses and gains due to shocks. They find that a one percent increase in losses resulting from a shock leads to a 10% decline in nutritional status as measured by height for age z-scores.

The studies mentioned above focus on how environmental and macroeconomic shocks affect child health. Due to the fact that the shock generally leads to a deterioration in the health environment, they cannot cleanly untangle a household income effect from a deterioration in the health environment. One study that attempts to isolate the income effect in order to explore the relative importance of time versus income for health is that by Miller and Urdinola [2007]. They use variation in coffee prices at birth interacted with county level measures of coffee production intensity to investigate how price shocks influence child mortality. They find that survival to age 5 decreases as coffee prices increase, thus, the opportunity cost of time dominates changes in income.

Shocks and cognitive development: While the effect of income shocks and health has been well studied, less is known about the the effect of income shocks and cognitive development. Although not specifically focused on shocks, there are studies that investigate how income or socio-economic status influences cognitive development. Blau [1999] uses the National Longitudinal Survey of Youth (NLSY) to study how parental income affects children's cognitive, social and emotional development. He uses mother and child fixed effect models to estimate the effect of current income, and grandparent fixed effects to estimate the effect of permanent income. In general he finds small and statistically insignificant effects of current income but larger permanent income effects. Todd and Wolpin [2004] use the same NLSY data to investigate how home inputs affect children's cognitive achievement. The rich data set allows them to estimate the effect of past and current inputs on children's Peabody Achievement tests in math and reading. While home inputs are not exogenous variables, they attempt to reduce any bias by using mother and child fixed effects and instrumenting for home and school inputs with a set of child and household characteristics such as birth weight, birth order, and mother's age. They find that home inputs do have a significant positive effect on academic achievement but the effect of school inputs is not significant.

There are only a handful of studies in developing countries that investigate how income shocks influence children's cognitive development. The income shock in most of these studies is due to the introduction of a government cash transfer program such as Opportunidades in Mexico, Bono de Desarrollo Humano (BDH) in Ecuador, and Atención a crisis in Nicaragua [Macours et al., 2008, Paxson and Schady, 2007, Fernald et al., 2008]. The study by Paxson and Schady in Ecuador uses the same sample of children that I use in my investigation to analyze how the BDH impacted children's health and cognitive development. They focus on rural children and find modest effects on physical and cognitive measures only for children in the lowest expenditure quartile. They argue that one reason why the transfer had little impact on height outcomes is that height reflects a child's cumulative history and thus is hard to change in the short run.

Early childhood nutrition and later educational attainment: While there are a few studies that investigate the impact of income on cognitive outcomes in developing countries, there are many studies that focus on how early childhood health affects later academic outcomes. For example, Glewwe et al. [2001] estimate the impact of nutrition on learning using a longitudinal data from the Philippines. Their estimation strategy uses household fixed effects to difference out any unobservables related to the household and then instruments for differences in siblings height by using height in first two years of life of oldest child. The identifying assumption is that growth after age two is uncorrelated with height up to the age of two. The authors recognize that this is a strong assumption but assert that finding the data to implement an iron clad identification strategy would be "nothing short of miraculous."

Using data from Zimbabwe, Alderman et al. [2006] move a step closer to implementing an iron clad identification strategy. Specifically, they use war and drought shocks to instrument for pre-school nutrition and use maternal fixed effects to control for the differential response of households to shocks. They find that improvements in nutritional status in pre-school had a positive impact on later height and grades completed. One problem with the estimation strategy in Alderman et al. [2006] is that it assumes that the shock affected children's academic outcomes only through its effect on height. However, the shock may have also impacted children's early childhood cognitive abilities which would have impacted later academic outcomes. If this is the case, then using shocks as an instrument for early health outcomes violates the strict exogeneity condition of instrumental variable techniques. My results suggest that indeed shocks impact children's cognitive development, and thus, should not be used as instruments for early health when assessing the relationship between early health and later education outcomes.

3 Background

3.1 Crisis

The 1998-2000 economic crisis in Ecuador was mainly due to the following exogenous factors: the El Niño phenomenon in 1997-1998, the fall in oil prices in 1998, and the 1997 international financial crisis. The El Niño phenomenon caused extremely heavy rainfall in Ecuador, and as a result, floods and landslides damaged much of the coastal area. Approximately 14% of the total agricultural land in the coastal area was damaged with rice, corn, coffee, and sugar cane being the most affected crops [Vos et al., 1999]. In addition to agriculture, El Niño had an adverse affect on the infrastructure and health environment of coastal provinces.

During the same year of El Niño, oil prices dropped and the international financial crisis peaked, all of which exposed the weaknesses of the banking system and precipitated a financial crisis within Ecuador. The banking system was severely affected by these events because they had lent heavily to sectors in coastal agricultural, oil, and other exports. The increase in their nonperforming loans and the decrease of credit from foreign banks led to intense liquidity pressure which caused the collapse of 1/3 of all Ecuadorian banks by 1999 and a speculative run on the sucre. The financial crisis caused President Mahuad to freeze bank deposits in March 1999 and it culminated with dollarization in January 2000 [Jacome, 2004, Beckerman and Solimano, 2002]. The exchange rate chosen for dollarization (25 sucres/dollar) however was very undervalued, and thus there was a sharp reduction in real wages right after dollarization [Beckerman and Solimano, 2002].

The economic crisis was characterized by a drastic increase in inflation which began rising in 1998, hit its peak at 108% in 2000, and then began to decline in 2001 (Figure 1).[1] While prices increased throughout Ecuador during the crisis years, the increase in prices for coastal and non coastal areas was not identical. Specifically, inflation rates were higher for the coastal region in 1998 because of the El Niño phenomena, but not so in 1999 once the banking crisis hit the whole country.

The rapid increase in prices caused real wages to decrease by 40% from January 1999-March 2000 [Inter American Development Bank, 2008]. As a result, aggregate household consumption declined by approximately 33% during 1999-2000 (Figure 2). In addition, unemployment doubled from 8.5% in May 1998 to 16.9% in June 1999. Although unemployment increased, labor participation of males and females actually increased in 1998 and 1999 (Figure 3), thus revealing a movement into the labor force especially among women. The increase in unemployment rates and the decrease in real income led to an increase in poverty rates by approximately 46% in coastal areas and 23% in highland areas.[2] Once again, coastal and highland regions did not follow the exact same pattern: poverty first increased in coastal areas between 1995 and 1998, and then increased in coastal and highland areas between 1998 and 1999 (Table 1). This variation in poverty trends is mainly due to the El Niño phenomenon which negatively impacted coastal areas in 1998.

In addition to drops in household's consumption levels, the crisis severely hurt the government's budget. The drop in oil prices, the El Niño, and the banking crisis all led to a massive increase in the public deficit, which forced the government to reduce social spending and delay payments to local governments and public servants [Vos, 2000]. Specifically, social spending decreased by approximately 50% from 1998 to 2000 and then increased back to pre-crisis levels in 2001 (Table 2). The government's inability to effectively respond to the crisis and instead its cuts in social spending and health programs would have exacerbated any negative income effects of the crisis on child health.

The review above on the Ecuadorian crisis reveals that the channels through which the crisis affected child health and cognitive development originate from two sources: a decrease in real income and a decrease in the health environment. If households were unable to smooth consumption, then a decrease in income would have caused them to decrease consumption of normal goods such as health care and food. A qualitative study by CEPLAES on the crisis reveals how the Ecuadorian crisis reduced the quantity and quality of food consumed and health services demanded. In the study there are many quotes such as the following that reveal the decline in consumption of the poor [Leon and Troya, 2000]:

> "Hemos dejado de comprar casi totalmente carne, arroz, azucar, papas. Todavía seguimos comprando, cuando hay plata fideos, sal, condimentos. Las verduras estan muy caras..."
>
> Translation: We have stopped buying almost totally, meat, rice, sugar, and potatoes. We still buy, when we have money, noodles, salt, and condiments. Vegetables are too expensive...

[1] According to Bank [2008] "The main driver of high dollar inflation after 2000 was the overshooting devaluation of the sucre in the months leading up to the currency switch: over the course of 1999, with inflation running at 60%, the sucre depreciated about 300%. Consequently, in the months preceding the dollarization of its economy Ecuador experienced inflation measured in sucres and price drops measured in dollars—the result being lagging dollar inflation, which led to a realignment of relative prices."

[2] 1995 and 1999 poverty rates used to calculate increase in poverty (Table 1)

"Si algún miembro familiar se enferma, ya no tenemos la posibilidad de decir: bueno, cualquier rato le llevamos al hospital, para hacerlo atender urgentamente porque la condición economica esta bastante baja..."

Translation: If a member of the family gets sick we can no longer say: ok, at any moment we can take him to the hospital to be attended to urgently because the economic conditions are extremely low.

4 Data and Descriptive Statistics

4.1 Data

The data that I use to investigate the effect of the economic crisis on children outcomes is data collected by the World Bank and the Government of Ecuador on health status and cognitive ability of children less than 6 years old during the baseline. The baseline survey was conducted between October 2003-September 2004 and the first follow-up was conducted between September 2005-January 2006. The baseline and follow-up data were collected to conduct an evaluation of the cash transfer program Bono de Desarrollo Humano, and thus, the sample is poorer and younger than the average population. Specifically, the sample was constructed by randomly selecting parishes within 6 provinces of Ecuador (3 coastal provinces and 3 highland provinces). Within the parishes, households that met the following criteria were randomly selected: households had to have preschool age children, no children older than 6 years old, and be eligible for the cash transfer program.[3] In total this sample consisted of 118 parishes, 3,426 households, and 5,547 children and is known as the BDH sample. To this sample 1,600 households (2,442 children) that were slightly too wealthy to be eligible for the transfer were added. Thus there are a total of 7,989 children under the age of 6 years old in the baseline survey. Of these children, 93% were re-surveyed in the follow-up, and 1,256 children who were born after the baseline were added to the follow-up. Therefore, in the follow-up there are 8,673 children, of which 7,417 were also in the baseline and 1,256 were born after.

The main health indicator of interest is children's height-for-age. Children's height was converted to age and sex adjusted z-scores using CDC 2000 standards. The cognitive development indicator of interest for children 36 months and older is the score from a vocabulary test called Test de Vocabulario en Imagenes Peabody (TVIP). This test is administered by showing a child slides that contain 4 pictures. For each slide, the child points to the picture that corresponds to the word stated by the interviewer. The raw scores are age-normed using a reference population of Mexican and Puerto Rican children. These norms set the mean at 100 and the SD at 15.

The timing of the crisis and the structure of the data is key for identifying the impact of the crisis on children's health and cognitive outcomes. Table 3 provides a time line for the crisis and data collection, and describes the age of the children at each point in time. In the sample less than 1% of the children are born in 1997 because to be included in the sample a household could not have children older than 72 months at the time of the survey. As you can see from the table, children affected by the crisis will be between the ages of 3-5 years during the baseline and 5-8 years in the first follow-up. Children born after the crisis will be 0-3 years old during the baseline and 0 - 5 years old during the first follow-up survey. Having more than one round of data allows comparisons of children's height and TVIP scores to be made for children of the same age that were differentially exposed to the crisis.

[3]Households who are in the bottom two quintiles of the SELBEN poverty index are eligible for the transfer.

In addition to data on child outcomes, I use data on prices to define the timing of the crisis. The price data I use is from the consumer price index that is provided by the Instituto Nacional de Estadisticas y Censos (INEC). It is monthly data from 1996-2005 at the province level.[4] I use the price data to define the month a province entered and exited the crisis. Specifically, I estimate the pre-crisis (1996-1997) average growth rate and use this average growth rate to predict prices during and after the crisis.[5] I then take the deviation of actual prices from predicted prices to calculate when a province entered and exited the crisis. The month a province entered the crisis is defined as the month when actual prices deviated from predicted prices by more than 5 standard deviations. The month a province exited the crisis is defined as the month when the deviation of actual to predicted prices was the largest. Figure 3 demonstrates how the dates of the crisis were defined for Azuay province. The vertical dotted lines represent the start and end month of the crisis.

As table 4 reveals, the timing of the crisis differed slightly by province with Los Rios being the first to enter the crisis in February 1998. This pattern is consistent with the fact that Los Rios was the province hardest hit by El Niño, and thus began to experience rising prices earlier than the rest of the sample provinces. Prices in the other provinces began to increase drastically in the summer and fall of 1998. Consequently, instead of defining crisis years as 1998-2000 for all provinces, I specify more precisely the timing of the crisis for each province using the months defined in table 4.

The exogenous variable of interest is length of exposure to the crisis. Length of exposure is measured by the number of months living in the crisis, with crisis months defined by table 4. Thus, the number of months living in a crisis is jointly determined by province and birth month. Birth months are labeled so that the youngest child born in December 2005 has a birth month of 1 all the way up to the oldest child born in October 1997, and has a birth month of 99. For children born before April 2001, exposure to the crisis is an non-decreasing function of date of birth as labeled by birth month. In other words, the closer a child's birth is to 2001, the less exposed a child is to the crisis. Thus, a child born in Los Rios in January 1998 (birth month 96) will be exposed to the crisis for 29 months while a child born in Los Rios in January 1999 (birth month 84) will be exposed to the crisis for 18 months. Any child born after March 2001 will have lived in the crisis for 0 months. A table showing how birth month and exposure are calculated can be found in the appendix.[6] The length of exposure to the crisis, as measured by the number of months living in the crisis, is the exogenous variable I use to estimate the effect of the crisis on children's height and TVIP scores.

4.2 Descriptive statistics on child health and cognitive outcomes

As mentioned in the section above, the households in the sample are poorer and younger than the average household in Ecuador. These characteristics are reflected in table 5. Specifically, mothers in the sample are young with a mean age of 24.4 years, many are not married (59%) and the mean years of education is 7.8. Children's cognitive outcome of interest for the analysis is their score on the Test de Vocabulario en Imágenes Peabody, which was administered to children 36 months and older. The mean standardized TVIP score for the sample is 86.58, which is almost one standard deviation below the mean of the reference population.[7] The mean height-for-age z-score is -1.11, which is more than one standard deviation below the mean of the

[4] Two series of price data was available. One from 1996-2004 and the other from 2005-2009. I used inflation rates from 2005 to construct one series of prices from 1996-2005.

[5] Average growth rate was estimated by running the following regression: $log\, price_{tm} = \beta_0 + \beta_1 time_t + \gamma_m + \varepsilon_{tm}$

[6] Unfortunately, I do not know know a child's birth location, and thus, I use vaccination location instead. Since most children received their immunizations before the age of 2, I believe this a good proxy for birth location.

[7] Reference population are Mexican and Puerto Rican children

reference population. The percent of children suffering from chronic malnutrition in the baseline is 24%.[8]

The density graphs in figure 5 show the distribution of height z-scores across waves. For the younger children (<36 months), the distributions follow very similar patterns across waves. On the other hand, for the older children (36-71 months), the distribution is shifted more to the left for the baseline compared to the follow-up. The shift in distributions between baseline and follow-up is consistent with the story that the crisis negatively affected older children (36-71 months) during the baseline but older children (36-71 months) during the follow-up were born after the crisis and thus not affected. The younger children were never affected by the crisis, and therefore, serves as a comparison group to see how the distributions in height shift from baseline to follow-up in the absence of the crisis. Unfortunately, since TVIP was only administered to children older than 35 months, the same comparison in TVIP trends between younger and older children cannot be made.

The mean number of months a child is exposed to the crisis is 5 months. However, conditional on being exposed to the crisis, the mean number of months exposed is 14.29. Figure 6 reveals the negative relationship between height or TVIP and number of months exposed to the crisis. While the relationship between height and exposure appears to be linear, the relationship between TVIP and exposure is a little more complicated. Specifically, the negative relationship between exposure and TVIP does not occur until after 10 months of exposure. The structure of the data imply that if a child was exposed to the crisis for 10 months, then the exposure occurred during their first 10 months of life. The negative relationship after 10 months is consistent with critical periods for the formation of receptive language which peaks at around 9 months [Grantham-McGregor et al., 2007]. Although figure 6 provides a good picture of the relationship between exposure and child outcomes, it does not control for any confounding factors such as age, time trends, and mother characteristics (which are discussed more in section 5 and 6).

5 Conceptual framework

5.1 Health

The following theoretical model for the demand for health draws heavily from models outlined in the papers by Currie [2000], Blau et al. [1996] and MaCurdy [1999]. Since health is a dynamic process, the model is a dynamic optimization problem where households maximize their expected present discounted value of lifetime utility. A household's expected present discounted value of life time welfare is

$$E_0 \sum_{t=0}^{T} (\frac{1}{1+\rho})^t U(C_t, L_t, H_t; \sigma, \omega_t) \tag{1}$$

In other words, life time utility is the expected discounted sum of time-specific utility. Utility in each period is a function of goods consumed by a household in period t, C_t, the health stock of children, H_t, leisure time, L_t and vectors of permanent and time-varying taste shifter variables, σ and ω_t. ρ is the discount factor and E is the expectation operator. The two assumptions made are that preferences are inter-temporally separable and that each utility function is increasing and concave in its arguments. Households choose their consumption, leisure, and health inputs in order to maximize their expected utility subject to the following constraints:

[8] Chronic malnutrition is measured by the percent of children with height-for-age z-scores less than -2.

$$A_{t+1} = (1 + r_t)A_t + y_t + w_t l_t - C_t - P_t N_t \tag{2}$$

$$H_{t+1} = h(H_t, N_t, K_t; D_t, \upsilon, \mu_t) \tag{3}$$

$$L_t + l_t + K_t = 1 \tag{4}$$

$$A_T \geq 0 \tag{5}$$

Equation 2 is the budget constraint, where A are assets, r is the interest rate, y is non-labor income, w is the wage, l is the number of hours of paid labor, and P_t is the price of health goods. Equation 3 is a health production function that states that inputs and health in time t affect health in the next period. Thus health in period $t + 1$ is a function of current health, H_t, material health inputs, N_t, a household's time spent on health production, K_t, the health environment, D_t, and permanent and time varying productivity shifters,υ and μ_t. υ will encompass all time invariant child and household characteristics that affect production such as gender and μ_t captures time variant characteristics such as age. Equation 4 is the time constraint and equation 5 is the terminal wealth condition. Solving the dynamic optimization problem leads to the following demand functions for C_t, N_t,K_t, L_t:[9]

$$N_t^*, C_t^*, K_t^*, L_t^* = f(P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}, H_t, D_t, \upsilon, \mu_t, \sigma, \omega_t)$$

Where λ_{1t} and λ_{2t} are the lagrange multipliers attached to the budget constraint and health production function, and thus they represent the shadow price of wealth and health. These equations reveal that current period decisions depend on expected future variables only through the shadow values λ_{1t} and λ_{2t}. In other words, decisions in period t, are related to variables outside period t, only through $\lambda_{1t,}\lambda_{2t}$. Substituting the solutions of N_t and K_t back into the health production function leads to the following dynamic health function:[10]

$$H_{t+1} = h^{'}(H_t, P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}, D_t, \upsilon, \mu_t, \sigma, \omega_t) \tag{6}$$

λ_{1t} and λ_{2t} are functions of every variable relevant to decision making in a lifetime context. In other words, they depend on not only current prices, wages, assets, non-labor income, interest rate, and variables affecting taste and productivity, but also on the moments of the distribution of future wages, prices, non labor income, interest rate, and variables affecting taste and productivity. [MaCurdy, 1985]. Assuming that the moments of the distribution of future variables are determine by current and past variables, and substituting in the determinants of H_t lead to the following reduced form equation for health:

$$H_{t+1} = h^{''}(A_0, H_0, y_t, P_t, w_t, r_t, \rho, D_t, M_t, \upsilon, \mu_t, \sigma, \omega_t) \tag{7}$$

Where M_t is a vector of $\{y_k, P_k, w_k, r_k, D_k, \mu_k, \omega_k\}\ for\, k = 1...t-1$. A_0 and H_0 are initial assets and health that are assumed to be given. Thus health in time *t+1* is a function of all current and past prices, wages,

[9]The maximization problem is presented in more detail in the appendix.

[10]Frisch demand functions are also referred to as marginal-utility-of-wealth constant demand functions. They allow for changes in relative prices to effect inter-temporal substitution in consumption [Kim, 1993].

non-wage incomes, interest rates, health environments, taste and productivity shifters, and a function of initial assets, initial health, and the discount rate.

5.2 Cognitive development

A child's cognitive development is also a dynamic process and thus is modeled in a similar fashion to that for health. Specifically, households maximize expected lifetime utility subject to a budget constraint, time constraint, a child's cognitive achievement production function, and the terminal wealth condition. A household's expected lifetime utility is the same as that in equation 1 expect H_t is replaced with G_t, a child's cognitive abilities. A child's cognitive production function is the following:

$$G_{t+1} = g(G_t, B_t, Z_t; R_t, \varepsilon_t, \eta) \tag{8}$$

where B are material inputs such as books and food, Z is a household's time input, R is the education and health environment, and η and ε_t are time invariant and time variant productivity shifters. Solving the household's maximization problem with respect to consumption, leisure, and cognitive inputs, leads to the following demand equations:

$$B_t^*, C_t^*, Z_t^*, L_t^* = f(P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}^c, R_t, G_t, \eta, \varepsilon_t, \sigma, \omega_t)$$

Where λ_{1t} and λ_{2t}^c are the lagrange multipliers attached to the budget constraint and cognitive production function, and thus they represent the shadow price of wealth and cognitive achievement. Plugging in B_t and Z_t back into the cognitive achievement production function leads to the following dynamic cognitive function:

$$G_{t+1} = g^{'}(G_t, P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}^c, R_t, \eta, \varepsilon_t, \sigma, \omega_t) \tag{9}$$

Assuming that expectations about the future are formed by current and past realizations, and substituting the determinants for G_t, λ_{1t} and λ_{2t}^c leads to the following reduced form equation:

$$G_{t+1} = g^{''}(G_0, A_0, y_t, P_t, w_t, r_t, \rho, R_t, M_t^c, \eta, \varepsilon_t, \sigma, \omega_t) \tag{10}$$

Where G_0 is initial cognitive abilities and M_t^c is a vector of $\{y_k, P_k, w_k, r_k, R_k, \varepsilon_k, \omega_k\}$ $for\ k = 1...t - 1$. Thus cognitive development in period $t + 1$ is a function of all current and past prices, wages, non-labor incomes, interest rates, time variant productivity and taste shifters, and the health and cognitive environment. It is also a function of time invariant productivity and taste shifters, initial assets, initial cognitive ability, and the discount rate.

5.3 Estimating the effect of the economic crisis

Equations 7 and 10 show that health and cognitive development are a function of current and past community characteristics, $\{P, R, D, r\}$. Ecuador's macro economic shock affected children's outcomes through its impact on past community characteristics. While the effect of the crisis is at the community level, the length of exposure to the crisis varies by birth month. The length of exposure to the crisis matters because every period matters in the production of current health and cognitive development. Thus I exploit the variation in exposure to the crisis to estimate the effect of the crisis on child outcomes.

Although the crisis provides an exogenous source of variation in the economic and health environment, I cannot run a reduced form regression of height or TVIP scores on the number of months living in the crisis and obtain an unbias estimate of the crisis. The main challenge with estimating the effect of the crisis on health and cognitive outcomes is disentangling the crisis effects from secular time trends and from age trends. Specifically, the timing and structure of the data implies that the older children in the sample are the ones affected by the crisis and thus should have worse z-scores. However, in general z-scores decrease with age because of growth faltering [Shrimpton et al., 2001]. Consequently, I cannot distinguish if older children have worse z-scores because of their age or because they were affected by the crisis or because of both the crisis and their age. Furthermore, if health and cognitive development are improving over time, then older children will also have worse outcomes. One reason why health might improve overtime is if health technology is improving overtime.

The strategy I use to disentangle the age and time trend effects from the crisis effect is to control for age using age fixed effects and control for time trends linearly using month of birth. The age-fixed effect means that I will be comparing outcomes of children of the same age. In order to compare outcomes of children of the same age and still have variation in exposure to the crisis, at least two rounds of data are needed. Thus, a 60 month old child born in Los Rios in January 1999 and surveyed in January 2004 will have been exposed to the crisis for 18 months while a 60 month old child born in January 2001 and surveyed in January 2006 will have had no exposure to the crisis. In order to capture secular time trends I control for birth month. Since improvements in the health and economic environment matter at the community level, I allow the trend to vary by province. As a result, the province specific time trend will capture any trends in the community characteristics from equations 7 and 10.

The second challenge with estimating the effect of the crisis on child outcomes is that while the crisis is exogenous, the way a household reacts to an economic shock is not. Specifically, mothers who choose to conceive during downturns may be different from mothers who choose to not conceive during this time. As a result the crisis effect may be capturing changes in the composition of women giving birth. In order to control for any compositional changes of women giving birth, I use mother fixed effects to estimate the effect of the crisis on child outcomes. Mother fixed effects will capture any time-invariant characteristics such as preferences that affect both the length of exposure to the crisis and a child's outcomes.

Consequently, the model I use to estimate the impact of the crisis on child outcomes is an age-fixed effect, mother fixed effect model, that controls for birth month at the province level. The mother fixed effect controls for any fixed mother, household, or community characteristics that are part of σ, υ, η in the reduced form equations 7 and 10. The birth month control captures any trends in community characteristics that affect children outcomes such as improvements in technology. The age fixed effect controls for the age of the child which is part of the vector μ_t or ε_t in the reduced form equations. The rest of the variables from the reduced form equations are captured in the error term. Specifically, the error term is composed of all individual unobservable characteristics, mother time-varying unobservable characteristics, and community time-varying unobservable characteristics not captured by the time trend. As long as the variables in the error term are not related to the crisis shock variable, then the estimates of the effect of the crisis on child outcomes will be unbiased. The exact empirical specification and identification assumptions are discussed in more detail in the following section.

6 Empirical strategy

6.1 Main specification

As mentioned above the difficulty with estimating the effect of the crisis on child outcomes is unraveling the crisis effect from time trends and age trends. I tackle the problem by defining a crisis shock variable as the number of months living in the crisis. Thus, the more exposed a child is to the crisis, the larger the shock variable. For children born after March 2001, exposure is 0. The advantage of having more than one round of data is that age fixed effects can be used without loosing the variation in the crisis variable. In other words, a 60 month old child in the baseline (born in Jan 99 and surveyed in Jan 04 from Los Rios) will have been exposed to the crisis for approximately 18 months while the 60 month old child in the follow-up (born in Jan 01 and surveyed in Jan 06 from Los Rios) will not have been exposed to the crisis. In addition, I allow time trends to enter the model linearly by controlling for birth month for each province. The exact equation that I will estimate is the following:

$$Y_{ihpma} = \beta_0 + \beta_1 S_{pm} + \beta_2 X_{ihpma} + \alpha_0 m + \sum_{p=1}^{5} \alpha_p m * prov_p + \delta_h + \gamma_a + \epsilon_{ihpma} \tag{11}$$

where Y_{ihpma} is the outcome variable of choice, either height-for-age or cognitive test score, for child i with mother h from province p, born in birth month m and is age a. S_{pm} is the number of months a child from province p and born in month m lived in the crisis, and X_{ihpma} is a vector of individual control variables. Birth month, m, is included in the specification in order to capture linear time trends in height or cognitive development. The birth month trend is interacted with a province indicator, $prov_p$, to allow time trends to vary by province. There are 6 provinces in the sample, thus the trend for the excluded province is captured by α_0. The province indicators are not estimated separately because there is no variation in provinces within a household. δ_h is the mother fixed effect, and γ_a is the age fixed effect. The age fixed effect is defined as age in months at the time of the survey. The mother fixed effect controls for any endogenous response of mothers to the shock. The mother fixed effect also controls for all fixed community level characteristics that affect health and cognitive development. Thus, the error term captures unobserved time variant mother characteristics, unobserved time variant community characteristics not capture by the trend, and unobserved individual characteristics.

The effect of the shock is identified by comparing height or cognitive outcomes of children of the same age but who were differentially exposed to the crisis. The mother fixed effect and birth month control forces this comparison to be made across sibling and across households that are from the same province. Table 6 demonstrates exactly how the effect of the crisis is identified. For clarity, estimation of child outcomes is simplified to only including the crisis shock variable, mother fixed effects, age fixed effects and the birth month interacted with a province indicator. Due to the fact that identification occurs by comparing households in the same province, the example below is restricted to only one province. The second to last column of table 6 calculates the difference in height or cognitive outcomes between siblings. The last column calculates the difference across households in the sibling differences. As table 6 reveals, the effect of the crisis is identified by comparing the sibling difference in height or cognitive z-scores across households whose children are born the same number of months apart. There are two different avenues through which this identification occurs. The first is demonstrated by household 1 and household 2. Sibling differences of household 1 in January 2004 are compared to the sibling differences of household 2 in January 2006. Identification occurs because household 1 and household 2 have children of the same age, but in 2004 the 60 month old child from household 1 was exposed to the crisis for 18 months whereas in 2006 the 60 month old child from household 2 was exposed to the crisis for 0 months. The second way identification occurs is demonstrated with household 3 and household 4. The sibling difference in household 3 is calculated for siblings that are the same age in different survey months and then compared to the sibling difference of children of the same age in household 4. Identification occurs because siblings of household 3 are the same age in different survey waves and are differentially exposed to the crisis. To disentangle the birth month effects from the crisis effect they are compared to siblings in household 4 that are the same number of months apart as siblings in household 3. As the two examples demonstrate, a necessary condition for identifying the effect of the economic crisis is that the number of birth months apart across siblings is the same across households that are being compared. Due to the fact that it is less likely that sibling are the exact same age across surveys, identification will occur mainly through the first avenue.

The identifying assumption for β_1 to be unbiased is that in the absence of the crisis sibling differences across households whose children are born the same number of months apart would be the same. Referring to the example in table 6, this means that in the absence of the crisis the sibling difference in outcomes for household 1 and household 2 would be the same. In order for this assumption to hold, time trends in height and cognitive development must be linear. Imposing a linear relationship means that the effect of being born 24 month apart on height differences is the same no matter what month children are born. Thus, differences in sibling outcomes due to being born 24 months apart in 1999 and 2001 is the same as differences due to being born 24 months apart in 2001 and 2003. One implication of the identifying assumption is that a shock (besides the economic crisis) that differentially affected one age group cannot occur. For example, β_1 will be bias if a shock occurred in 2005 that positively affected younger children's height more than older children's height. If this is the case, then the difference in sibling outcomes from household 1 would no longer be the same as the sibling difference in household 2 in the absence of the 1998-2001 economic crisis.

7 Preliminary results:

7.1 Height and TVIP

Table 7 and table 8 show the results of regressing height for age z-scores or TVIP scores on the number of months living in the crisis. Column 1 estimates the effect of the crisis without using mother fixed-effects. Due to the fact that mother fixed effects uses only children with siblings to conduct the estimation, column 2 estimates the effect of the crisis on the smaller sample of children who have at least one sibling. Column 3 includes mother fixed effects and column 4 adds control variables. Control variables include an indicator for a child being male, an indicator for whether the child was in the hospital in the last year, an indicator for whether a child's father lives at home, a continuous birth order variable, and indicators for the month in a given year that a child was born. The last column allows the effect of the crisis to vary for Los Rios province. Los Rios was the province hardest hit by El Niño and thus the effect of the crisis might be larger in this province. All columns contain age in months fixed effects and control for birth month trends. Standard errors are clustered at the parish level.

The first column in table 7 indicates that the economic crisis did have a negative impact on children's height. The magnitude of the coefficient on the number of months living in a crisis decreases when looking at only the subsample of children with a sibling. One reason for this decline in magnitude is that children in single child households are older than children in households with at least two children. [11] Consequently the subsample of children in column 2 are less exposed to the crisis. The magnitude of the coefficient remains fairly stable when mother fixed effects are included in column 3, thus suggesting that the effect of the crisis is not driven by the selection of women giving birth during the crisis. The coefficient also remains fairly stable after the inclusion of control variables (column 4). Column 5 shows that the effect of the crisis in Los Rios was larger than the effect in the other 5 provinces, but the difference was not significant. Using the coefficient from column 4, the results suggest that if a child lived in the crisis for a whole year, he/she would be .07 standard deviations shorter. The average height of children in the baseline survey is -1.11 standard deviations, thus one year of crisis exposure led to a 6% reduction in a child's height.

Results for standardized TVIP indicate that the economic crisis also had a negative impact on cognitive development. Table 8 shows estimates of TVIP scores on the number of months living in the crisis for children that are older than 35 months. The reason for the smaller age range is that the TVIP test was only conducted on children older than 35 months. Similar to the set up in table 7, column one estimates the effect of the crisis for all children older than 35 months without using mother fixed effects. Column two estimates the effect of the crisis on a smaller sample of children that are over the age of 35 months and have a sibling over the age of 35 months. Unlike the height results, decreasing the sample to households with at least 2 children older than 35 months does not change the magnitude of the coefficient. One reason for the lack of change is that the average age of children in households with one child over the age of 35 is the same as the average age of children in households with two children over the age of 35.[12] When mother fixed effects are added to the model (column 3) the coefficient increases thus suggesting that mothers with characteristics associated with better child outcomes are the ones more likely to have a child during the crisis. One reason why results in tables 7 and 8 do not follow the exact same pattern is that the sample of mothers with at least 2 children over the age of 35 months is different from that with at least two children (of any age) in the height regressions. Specification 4 adds control variables to the model and similar to estimations on height, the control variables do not significantly change the magnitude of the coefficient on the exposure variable. Using the coefficient in column 4, the results from table 8 suggest that one year living in the crisis reduces TVIP scores by approximately 3.36 points. The average TVIP score at the baseline is 86.58, thus, one year in the crisis reduced TVIP scores by 4%.

7.2 Mechanisms

The three main pathways through which the crisis could have led to a deterioration of child health and cognitive development were through reduced consumption of health and cognitive inputs, reduced time inputs from the mother, and a deterioration of the health environment. Unfortunately, the data does not allow for a comprehensive examination of the mechanisms driving the negative crisis effect. The survey does, however, ask a few retrospective questions related to prenatal and post natal care. I examine the impact of the crisis on these measure to assess some potential pathways.

Information on the number of months a child breastfed and the immunizations a child received was collected for all children in the sample. In addition to this information, the data also contains information on the place of birth and prenatal care for the last child born to a mother in 2003 and 2005. Due to the fact that breastfeeding is time intensive, any changes in breastfeeding patterns resulting from the crisis will give

[11] T test was conducted to compare the age of children who had no siblings to those children with a sibling. The t-statistics was significant at the 99% level.

[12] T tests was conducted to compare the age of children older than 35 months who had no siblings older than 35 months to those children older than 35 months with a sibling older than 35 months. The t-statistic for age was not significant.

us insight on changes in a mother's time input. Since child vaccines and prenatal care are free in Ecuador, any changes in these variables are more likely to indicate changes in time inputs (time it takes to take a child to get vaccinated) and/or the health environment (vaccine availability in the parish). The information on a child's place of birth is with respect to being born in a private clinic, public health facility, at home, or NGO facility. Observing whether there are any changes in the frequency of being born in a private clinic will provide insight on changes in health inputs that are due to the negative income effect of the crisis.

In order to investigate the impact of the crisis on potential pathways, I estimate a model similar to the one in equation 11 except instead of using the number of months exposed to the crisis, I use an indicator for exposure to the crisis. The dependent variables examined are the number of months a child was breastfed, an indicator for whether the child received at least 2 vaccines, an indicator for whether the child was born in a private clinic, and an indicator for whether the mother received prenatal treatment.[13] Estimations are conducted only on children who have siblings because mother fixed effects are used. Table 9 reveals that the crisis had no impact on immunizations, prenatal care, and breastfeeding. One potential reason why the crisis had no effect on children's immunizations is that national immunization campaigns sponsored in part by international institutions were conducted in 1999, and thus, any potential impact of the crisis on vaccinations would have been mitigated.[14] The crisis does appear to have a negative effect on the probability of being born in a private health clinic. Although table 9 just skims the surface of potential pathways through which the crisis operated, the results suggests that the negative impact of the crisis on child outcomes was more due to decreases in material health inputs (due to negative income effects) than decreases in time inputs or availability of health services.

8 Conclusion

8.1 Discussion

The results in the section above indicate that Ecuador's economic crisis led to a deterioration in child's health and cognitive development that persisted 3-5 years later. Specifically, if a child lived in the crisis for a full year then he/she would be .07 standard deviations shorter and have TVIP scores that were 3.36 points lower. It is important to emphasize that these results are specific to the population studied: young families who are in the bottom two poverty quintiles. Furthermore, mother fixed estimations use only a subsample of families that have at least two children, and even more limiting, the TVIP mother fixed effects estimations use only families that have at least two children older than 35 months. While these results cannot be generalized to Ecuador's population as a whole, they do provide insight for an important segment of the population: young, poor families with multiple children.

In addition to estimating the effect of the crisis on child outcomes I attempt to investigate potential pathways through which the crisis affected child outcomes. Unfortunately, the data does not have detailed retrospective information on a mother's time use or on a child's health/cognitive inputs; consequently, I am only able to skim the surface on potential pathways. From the results in table 9 it does not seem like the crisis affected a mother's time use with respect to breastfeeding, or the demand/supply of prenatal care or immunizations (which are free in Ecuador). The crisis did, however, decrease the use of private

[13] The reason for using an indicator for whether or not a child received at least 2 vaccines is that there are 2 vaccines that were recommended by the Ministerio de Salud Pública in 1999 for children under the age of 12 months (BCG, OPT). Campos, C. (2009) Introducción nuevas vacunas en el esquema de vacunación del Programa Amplaido Inmunaciones. Information on recommended vaccination age found at the following URL: http://www.bvv.sld.cu/ibv/?pg=cip&r=es&country=ec

[14] http://www.paho.org/english/ad/fch/im/sne2104.pdf

health facilities. Thus, these results suggest that the negative income effect of the crisis on material inputs dominated any time or supply effects.

While other studies have shown that macroeconomic shocks adversely affect children's health, this is the first study to my knowledge that also investigates the effect on child's cognitive development. These finding are important not only because we care about child outcomes in their own right but also because insults to a child's development persist into the future unless promptly and adequately responded upon. Although not long term, these results show that the negative impact of the crisis persisted 3-5 years later, and therefore, stress the importance of creating programs that mitigate the effect of economic shocks on early childhood outcomes.

8.2 Next steps/extensions

Thus far I have estimated the impact of the Ecuadorian crisis using an age-fixed effect, mother fixed effect model that controls for birth month trends. The following sections outlines future analysis that I plan to conduct. The first extension is to re-estimate the effect of the crisis, allowing exposure to the crisis to begin at the time of conception. In the previous analysis I have assumed that the crisis will only affect children after they are born. However, the crisis might also affect the health of the baby in utero. Although we do not see a change in prenatal care during the crisis there might be other pathways, such as diet and exercise, for which the crisis affects the health of a baby in utero. Due to the fact that exposure to the crisis in utero will probably have a different effect on child outcomes than exposure to the crisis out of utero, it will be important to allow exposure to the crisis to enter the estimation equation separately for in and out of utero.

In estimating the effect of the crisis on child outcomes I have used monthly prices to define the timing of the crisis. Using these crisis months, I constructed a variable for a child's exposure. Implicit in this construction was that every month exposed to the crisis carried equal weight. I plan to go a step further and introduce an intensity dimension by directly using prices in the estimation equation. Since a child's development is the most vulnerable in the first two years of life, I plan to use prices during this period to estimate the effect of the crisis. In other words, using the same mother fixed effect, age fixed effect model, I will regress child outcomes on a child's first two year inflation rate. The coefficient of interest will thus reveal how inflation, the main characteristic of the crisis, affects child outcomes.

In addition to analyzing the average effect of the crisis, I plan to analyze the differential effect of the crisis in areas with high and low health care availability. Due to the fact that most early childhood social programs in Ecuador are run by health centers, the closer a family is to health centers, the more access the family has to health-related social programs such as Maternidad Gratuita, Programa Nacional de Micronutrients, and Universal immunization program. These programs provide free vaccinations, early childhood and prenatal care, and iron and vitamin A supplements. Therefore, access to health centers should mitigate the effect of the crisis, since individuals closer to these facilities are more likely to receive health care and nutritional supplements during and after the crisis. The benefit of analyzing the differential effect of the crisis with respect to heath care availability is that yearly data on the number of health centers is available at the parish level from the Estadisticas de Recursos y Actividades de Salud. Thus, I will construct a measure of health care availability at the parish level and interact it with the crisis exposure variable. The coefficient in front of the interaction will provide an estimate for the differential effect of the crisis with respect to health care availability.

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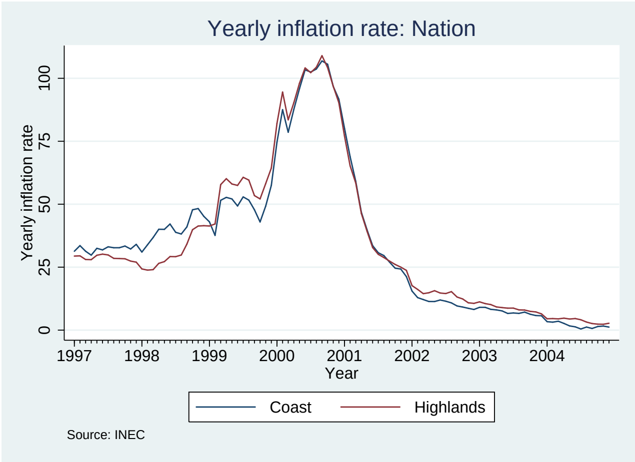
Figures

Figure 1: Price levels and inflation rate



Source: INEC, CPI index

Figure 2: Aggregate household consumption

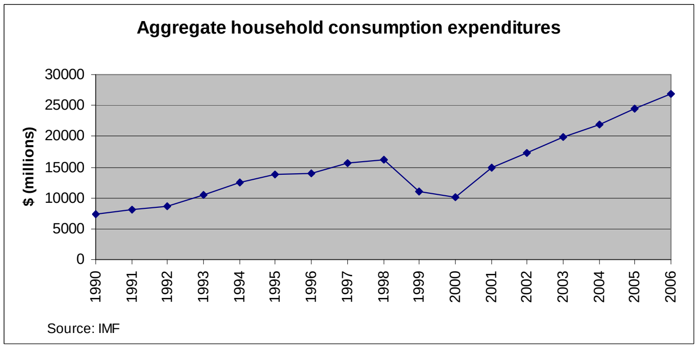
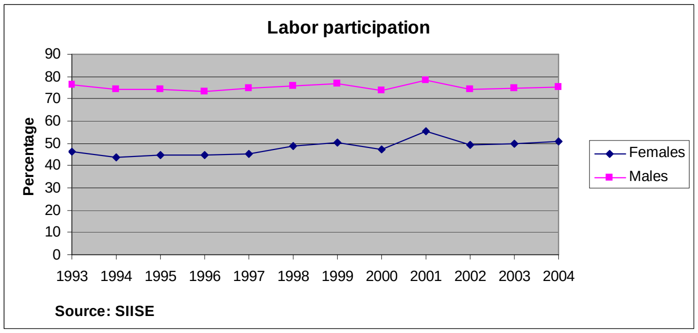


Figure 3: Labor participation rate



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[15] Labor participation is calculated as the ratio of the number of individuals 12 years old andolder who are economically active, to the total number of individuals 12 years old and older.

Figure 4: Actual and predicted prices

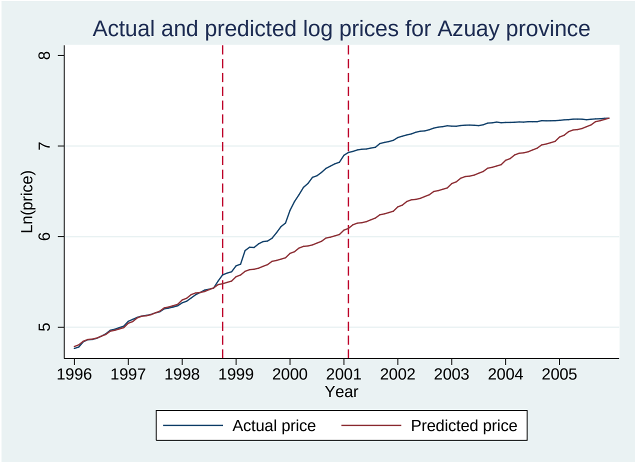


Figure 5: Density graphs for height z-scores

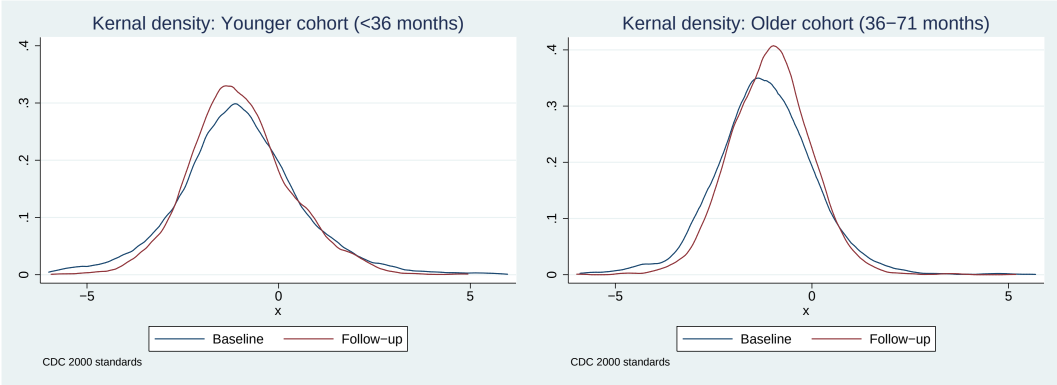
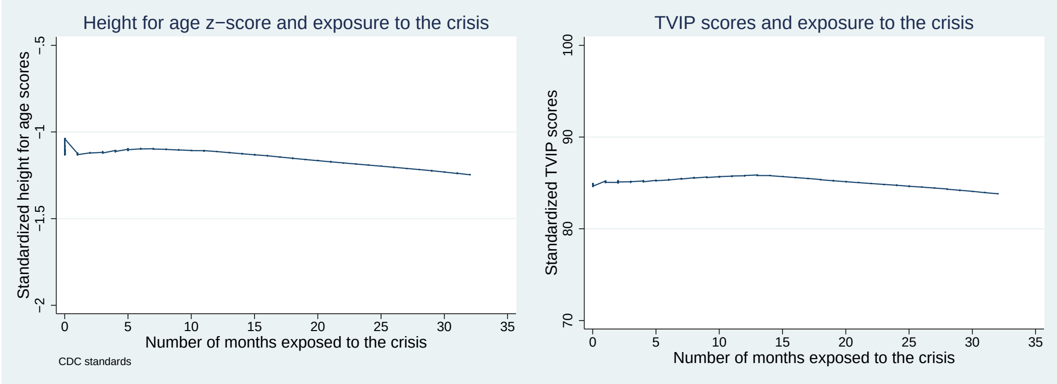


Figure 6: Lowess graphs height z-scores and TVIP on exposure



Tables

Table 1: Poverty Index

Poverty Index (%)

	1995	1998	1999
Coast	36.1	46.4	52.8
Sierra (highlands)	41.7	42.2	51.4

Source: INEC

SIISE calculations using ECV 1995, 1998, 1999

Table 2: Social spending (millions $) in nominal terms

Year	Health	Other *	Total	GDP	%GDP
1996	198	778	976	21,267.9	4.6%
1997	191	707	898	23,635.6	3.8%
1998	183	729	912	23,255.1	3.9%
1999	119	480	599	16,674.5	3.6%
2000	103	364	467	15,933.7	2.9%
2001	189	760	949	21,249.6	4.5%
2002	268	887	1,155	24,899.5	4.6%

Source: Informe de Desarrollo Social 2007

*Other includes spending on education, social inclusion, work, and urban and housing development

Table 3: Time line

	Crisis years					Baseline (Oct 2003-Sept 2004)		Follow-up 1 (Sept 2005-Jan 2006)	
	1998	1999	2000	2001	2002	2003	2004	2005	2006
Age	0	1	2	3	4	5	-	7	8
		0	1	2	3	4	5	6	7
			0	1	2	3	4	5	6
				0	1	2	3	4	5
					0	1	2	3	4
						0	1	2	3
							0	1	2
								0	1
									0

Table 4: Monthly price inflation by province

	Non crisis mean	Crisis mean	Crisis months
Azuay	1.27	5.08	Oct 1998-Feb 2001
Del Oro	1.09	4.51	May 1998-Dec 2000
Esmeraldas	1.13	4.98	Sep 1998-Dec 2000
Loja	1.2	5.09	Aug 1998-Oct 2000
Los Rios	1.25	5.41	Feb 1998-Jun 2000
Pichincha	1.07	4.62	Sep 1998-Mar 2001

Source:Prices from INEC

Table 5: Descriptive statistics from Baseline

	Mean	SD	N
Child's height for age z-score	-1.11	1.45	7017
Child's standardized TVIP score	86.58	17.17	3438
Child's age in months	34.81	17.75	7297
Child is male	0.52	0.50	7311
Child has no health insurance	0.95	0.23	7311
Mother's years of education	7.79	3.42	7296
Mother's age	24.43	5.51	7305
Mother is married	0.41	0.49	7311
Children 0-5 years in household	1.95	0.82	7311
Father lives at home	0.74	0.44	7296

*Sample consists of all children <72 months at baseline that were also in follow-up.

Table 6: Identification

Simplifying problem to: $Y_{ihpma} = \beta_1 S_{pm} + \alpha_0 m + \sum_{p=1}^{5} \alpha_p m * prov_p + \delta_h + \gamma_a$

HH	Child	Prov	Survey month	Birth month	Age in months	♯ of months in the crisis	δ_h	γ_a	$\beta_1 S_{pm}$	$\alpha_0 m + \sum_{p=1}^{5} \alpha_p m * prov_p$	Sibling Difference $(Y_{1hpma} - Y_{2hpma})$	HH diff-in-diff
1	1	6	Jan 04	84 (Jan 99)	60	18	δ_1	γ_{60}	$\beta_1 18$	$\alpha_0 84$		
1	2	6	Jan 04	48 (Jan 02)	24	0	δ_1	γ_{24}	0	$\alpha_0 48$	$=\gamma_{60} - \gamma_{24} + \alpha_0(84-48) + \beta_1 18$	$= \beta_1 18$
2	1	6	Jan 06	60 (Jan 01)	60	0	δ_2	γ_{60}	0	$\alpha_0 60$		
2	2	6	Jan 06	24 (Jan 04)	24	0	δ_2	γ_{24}	0	$\alpha_0 24$	$=\gamma_{60} - \gamma_{24} + \alpha_0(60-24)$	
3	1	6	Jan 04	84 (Jan 99)	60	18	δ_3	γ_{60}	$\beta_1 18$	$\alpha_0 84$		
3	2	6	Jan 06	60 (Jan 01)	60	0	δ_3	γ_{60}	0	$\alpha_0 60$	$=\alpha_0(84-60) + \beta_1 18$	$= \beta_1 18$
4	1	6	Jan 04	48 (Jan 02)	24	0	δ_4	γ_{24}	0	$\alpha_0 48$		
4	2	6	Jan 06	24 (Jan 04)	24	0	δ_4	γ_{24}	0	$\alpha_0 24$	$=\alpha_0(48-24)$	

Table 7: Height for age z-scores on exposure to the crisis

Height for age z-score on the number of months exposed to the crisis	(1)	(2)	(3)	(4)	(5)
Number of months living in the crisis	-0.013***	-0.006*	-0.005*	-0.006**	-0.005*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Male				-0.076***	-0.076***
				(0.029)	(0.029)
Child was in the hospital in the last year				-0.115*	-0.112*
				(0.060)	(0.060)
Father lives at home				0.187***	0.187***
				(0.059)	(0.059)
Birth order				-0.083*	-0.085*
				(0.044)	(0.044)
Los Rios* Months living in the crisis					-0.007
					(0.007)
Constant	-0.255	-0.205	0.055	0.132	0.135
	(0.305)	(0.308)	(0.317)	(0.353)	(0.353)
Household fixed effects	no	no	Yes	Yes	Yes
Birth month trend*Province	Yes	Yes	Yes	Yes	Yes
Observations	15,147	11,451	11,451	11,451	11,451
Adjusted R2	0.084	0.102	0.137	0.140	0.140

Robust standard errors clustered at the parish level. *** p<0.01, ** p<0.05, * p<0.1 All specifications contain age-in-month indicators and specification 4 and 5 contain 12 indicators indicating the month in which a child was born. In specifications 1 and 2 , number of households=4,729 and number of children=8,393. In specifications 3-5, number of households=2,821 and number of children=6,485. Children included are those with z-scores less than 6 standard deviations from the reference population who have non-missing data on all the control variables.

Table 8: TVIP score on exposure to the crisis (children >35 months)

Standardized TVIP on the number of months exposed to the crisis	(1)	(2)	(3)	(4)	(5)
Number of months living in the crisis	-0.20***	-0.20***	-0.27***	-0.28***	-0.25***
	(0.05)	(0.07)	(0.07)	(0.07)	(0.07)
Male				1.88***	1.90***
				(0.46)	(0.46)
Child was in the hospital in the last year				0.81	0.78
				(1.42)	(1.43)
Father lives at home				1.94	1.96
				(1.46)	(1.46)
Birth order				1.69	1.68
				(1.26)	(1.26)
Los Rios* Months living in the crisis					-0.15
					(0.18)
Constant	92.45***	93.29***	75.08***	65.64***	66.04***
	(4.09)	(5.18)	(3.52)	(6.49)	(6.47)
Household fixed effects	no	no	Yes	Yes	Yes
Birth month trend*Province	Yes	Yes	Yes	Yes	Yes
Observations	7,600	3,576	3,576	3,576	3,576
Adjusted R2	0.156	0.184	0.186	0.194	0.194

Robust standard errors clustered at the parish level. *** p<0.01, ** p<0.05, * p<0.1 All specifications contain age-in-month indicators and specification 4 and 5 contain 12 indicators indicating the month in which a child was born. In specifications 1 and 2 , number of households=4,427 and number of children=5,791. In specifications 3-5, number of households=1,427 and number of children=2,791. Children included are those who have non-missing data on all the control variables.

Table 9: Mechanisms

Independent variable: Indicator for exposure to the crisis:	
Child has at least 2 vaccinations	-0.00
	(0.01)
Number of observations	10,028
Adjusted R2	0.453
Number of months breast fed	-0.05
	(0.14)
Number of observations	11,108
Adjusted R2	0.161
Child was born in private clinic	-0.06*
	(0.03)
Number of observations	6,834
Adjusted R2	0.016
Mother had prenatal treatment	0.04
	(0.03)
Number of observations	6,834
Adjusted R2	0.033

Robust standard errors clustered at the parish level. *** p<0.01, ** p<0.05, * p<0.1 All specifications contain age-in-month indicators and an indicator for whether the child is male. Sample consists of all children from households with at least two children.

Appendix:

A.1 Exposure and month of birth table

Exposure to the crisis is determined by month of birth and province. Crisis months for each province are defined by table 4. The table below indicates how birth month and province determine the exposure to the crisis for two provinces, Los Rios and Azuay.

Table 10: Exposure to crisis and birth month

Birth month	Birth month label	Exposure for Los Rios	Exposure Azuay
Dec 05	1	0 months	0 months
.	.	.	.
.	.	.	.
Jan 05	12	0 months	0 months
.	.	.	.
.	.	.	.
Jan 04	24	0 months	0 months
.	.	.	.
.	.	.	.
Jan 03	36	0 months	0 months
.	.	.	.
.	.	.	.
Jan 02	48	0 months	0 months
.	.	.	.
.	.	.	.
Feb 01	59	0 months	1 months
Jan 01	60	0 months	2 months
.	.	.	.
.	.	.	.
Ju1 00	66	0 months	8 months
Jun 00	67	1 months	9 months
.	.	.	.
.	.	.	.
Jan 99	84	18 months	26 months
Dec 98	85	19 months	27 months
Nov 98	86	20 months	28 months
Oct 98	87	21 months	29 months
Sept 98	88	22 months	29 months
.	.	.	
.	.	.	.
Feb 98	95	29 months	29 months
Jan 98	96	29 months	29 months
Dec 97	97	29 months	29 months
Nov 97	98	29 months	29 months
Oct 97	99	29 months	29 months

A.2 Dynamic optimization problem, which closely follows MaCurdy [1985, 1999] and Currie [2000]

$$max_{\{C_t, L_t N_t, K_t\}} E_0 \sum_{t=0}^{T} \left[(\frac{1}{1+\rho})^t U(C_t, L_t, H_t; \sigma, \omega_t) \right]$$

$$s.t.$$

$$A_{t+1} = (1 + r_t)A_t + y_t + w_t l_t - C_t - P_t N_t$$

$$H_{t+1} = h(H_t, N_t, K_t; D_t, \mu_t, \upsilon)$$

$$L_t + l_t + K_t = 1$$

$$A_T \geq 0$$

[16]

In order to solve the maximization problem, dynamic programing methods are used. Specifically, Bellman's Principle of Optimality leads to the following value function:

$$V(A_t, H_t) = max_{\{C_t, L_t, K_t, N_t\}} \left[U(C_t, L_t, H_t; \sigma, \omega_t) + \frac{1}{1+\rho} E_t \left\{ V\left(A_{t+1}, H_{t+1}\right) \right\} \right] \quad (12)$$

Solving the following maximization problem and assuming interior solutions leads to the following first order conditions:

$$\frac{\partial U(C_t, L_t, H_t; \sigma, \omega_t)}{\partial C_t} = \lambda_{1t} \quad (13)$$

$$\frac{\partial U(C_t, L_t, H_t; \sigma, \omega_t)}{\partial L_t} = \lambda_{1t} w_t \quad (14)$$

$$\lambda_{2t} \frac{\partial h(H_t, N_t, K_t; D_t, \upsilon, \mu_t)}{\partial N_t} = \lambda_{1t} P_t \quad (15)$$

$$\lambda_{2t} \frac{\partial h(H_t, N_t, K_t; D_t, \upsilon, \mu_t)}{\partial K_t} = \lambda_{1t} w \quad (16)$$

$$\lambda_{1t} = \frac{1}{1+\rho} E_t[\lambda_{1t+1} * (1 + r_t)] \quad (17)$$

[16] Terminal condition on wealth and health, see MaCurdy [1985]

$$\lambda_{2t} = \frac{\partial U(C_t, L_t, H_t; \sigma, \omega_t)}{\partial H_t} + \frac{1}{1+\rho} E_t[\lambda_{2t+1} * \frac{\partial H_{t+1}}{\partial H_t}] \tag{18}$$

Where λ_{1t} and λ_{2t} are the lagrange multipliers attached to the budget constraint and health production function, and thus they represent the shadow price of wealth and health. The last two equations use the following identities: $\lambda_{1t} = \frac{\partial V_t}{\partial A_t}$ and $\lambda_{2t} = \frac{\partial V_t}{\partial H_t}$. The first order conditions imply the following demand equations[17]:

$$N_t^* = f(P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}, D_t, H_t, \sigma, \omega_t, \upsilon, \mu_t)$$

$$K_t^* = f(P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}, D_t, H_t, \sigma, \omega_t, \upsilon, \mu_t)$$

These equations reveal that current period decisions depend on expected future prices and decisions only through the shadow values λ_{1t} and λ_{2t}. In other words, decisions in period t, are related to variables outside period t, only through $\lambda_{1t,}\lambda_{2t}$.Substituting N_t and K_t back into the health production function, yields the dynamic function for health:

$$H_{t+1} = h^{'}(H_t, P_t, w_t, r_t, \rho, \lambda_{1t}, \lambda_{2t}, D_t, \sigma, \omega_t, \upsilon, \mu_t)$$

λ_{1t} and λ_{2t} are functions of every variable relevant to decision making in a lifetime context. In other words, they depend on all prices, wages, assets, income, interest rate, and characteristics observed in time t and on the distribution of future wages, prices, income, interest rate, and characteristics MaCurdy [1985]. Assuming that the moments of the distribution of future variables are determine by current and past variables, and substituting in the determinants of H_t lead to the following reduced form health function:

$$H_{t+1} = h^{''}(A_0, H_0, y_t, P_t, w_t, r_t, \rho, D_t, M_t, \sigma, \omega_t, \upsilon, \mu_t)$$

Where M_t is a vector of $\{y_k, P_k, w_k, r_k, D_k, \omega_k, \mu_k\}$ and $A_0$and H_0 are initial assets and health.

[17] Due to the fact that utility is strictly concave, the first order conditions can be inverted to give consumption and labor equations [Browning et al., 1985]