A Framework for the Analysis of Early Life Interventions

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Abstract

In this paper we propose and create a framework to estimate height and weight production functions. We take advantage of databases for two developing countries, Guatemala and the Philippines, which include detailed anthropometric and diet information for children between 0 and 24 months old. The main advantage of these databases is that the children are followed for extended periods of time so panel data fixed-effects and instrumental variables are possible solutions to omitted variables and measurement error problems. We find that protein intake plays an important and positive role in the height and weight production function during the first two years of life. We currently are embedding these production function estimates within a model of parental behaviors to explore, for example, the impacts of parental beliefs regarding normal anthropometrics on their investments in their children. Preliminary results suggest that these impacts are considerable.

1. Introduction

Over 170 million children under five years old in developing countries are stunted, as indicated by having measured height more than two standard deviations below World Health Organization standards for healthy children (de Onis, Blössner and Borghi 2011). Indeed, being stunted is the primary indicator used for the estimate in a well-known recent series on early childhood development in *The Lancet*, which shows that over 200 million children younger than five years-old in developing countries are not likely to meet their developmental potential, with negative implications for their subsequent education and productivity over their life cycles ((Grantham-McGregor, et al. 2007); (Engle, et al. 2007); (Engle, et al. 2011)). Relatedly, there is increasing evidence that early life undernourishment is at least associated with and possibly causes reduced educational attainment, adult cognitive skills, wages, and other important life outcomes (Victora, et al. 2008): (Behrman, et al. 2009); (Hoddinott, et al. 2008); (Maluccio, et al. 2009)). At the same time, there has been increasing concern about obesity among young children in developing countries, with estimates that indicate these conditions are rapidly growing although are still much less prevalent than stunting (de Onis, Blössner and Borghi 2010).

Despite this widespread concern about malnutrition among preschool children in developing countries, there is limited systematic knowledge about the production technology for anthropometric indicators such as height and weight in those countries. One of the main difficulties that have to be addressed is the endogeneity of inputs into the production functions, Liu, Mroz and Adair (2009) and Akin et al (1992) show that families in the Philippines tend compensate for bad health outcomes. The few studies that exist are suggestive, but make fairly strong assumptions to control for endogenoeity. In the estimation of a height production function for Guatemala, Griffen (2013), assumes that past inputs have no effect on current height, thus history plays little role for current height and uses instrumental variables to correct for endogeneity that are valid under his restrictive assumptions about the height production function. For the estimation of a height production function in the Philippines, de Cao (2011) used fixed-effect methods, but she refrains from using instrumental variables to account for further endogeneity problems due to the instruments' weakness.

In this paper we use rich longitudinal data from Guatemala and the Philippines that includes detailed information on anthropometric outcomes, nutrition, and other inputs for relatively short intervals of two-three months to estimate height and weight production functions. In our specifications, height growth depends on calorie and protein consumption, breastfeeding, diarrhea, and a fixed genetic endowment. We contribute, building on the previous literature, by estimating similar production functions for two different countries and focusing on height and weight.

We also add to previous research by using fixed-effects methods and instrumental variables, which control for the endogeneity detected by Liu, et al (2009) and Akin et al (1992), under less restrictive assumptions than in previous studies. Additionally, we do not consider just calories, which is the nutritional input usually considered in the economic literature, but compare the effect of net calories with protein intakes. Finally we embed our production function within a structural model of how parents decide to invest in the nutrition of their children and find, for example, that changing beliefs about what are normal heights and weights alter substantially investments in the children.

The estimation of production function allows us to calculate the effects of early interventions, in a similar way as Cunha and Heckman (2008) and Cunha, Heckman and Schennach (2010) did for the cognitive and non-cognitive model. Early interventions have the advantage of being more efficient than interventions in adolescence or adulthood, in terms of adult health, savings and labor returns (Heckman 2012).

The paper is divided in five sections, the first one is this introduction, the second details the data, the third discusses the specifications used, the fourth shows the estimation results, and the last section discusses.

2. Specifications of Height and Weight Production Functions

In this section we present the model for the height and weight production functions. We take advantage of the research that estimates production function for the formation of cognitive and non-cognitive skills. For instance, Todd and Wolpin (2007) consider the different assumptions that underlie different specifications of the production function of cognitive skills; Cunha and Heckman (2007) study the theoretical implications of production function for skill formation, while Cunha and Heckman (2007) and Cunha et al (2010) estimate the technology of skill formation on cognitive and non-cognitive skills.

Height growth is measured as the difference in centimeters between two periods. According to (Victora, et al. 2008), height is affected by genetic and environmental conditions and stunting is due to lack of proper nutrition and the presence of diseases. Additionally, a report from FAO, WHO and UNU (1995) indicates that the human body requires certain amounts of energy and protein to maintain long-term good health and that these requirements depend on several other factors, including the actual weight of the children and whether they are being breastfeed. Among diseases that affect growth, Walker et al (2011) suggest that diarrhea contributes to stunting, and other diseases such as malaria also have long lasting effects on children's development. However only the data on diarrhea is similar for Guatemala and the Philippines in the datasets that we use. Thus the specifications we use for height production functions include nutrition, breastfeeding, presence of diarrhea and a fixed genetic factor as determinant. In the case of the weight production function, we follow a similar approach to the height specification. However, in the economic literature there are few attempts to estimate weight production functions despite the fact that both stunting and being underweight are the two main, and very similar, sources of child deaths (Black, et al. 2013).

It is important to study height production functions at early ages, since stunting tends to occur in early in childhood, when growth velocity is the highest (Martorell, Kahn and Schroede 1994). We focus our estimates on the period from 0 to 24 months of age, which is widely considered a critical window for post-birth nutritional investments.

2.1. Height and Weight Production function

Let $\hbar_{i,t}$ denote child i height at age t, $w_{i,t}$ the child's weight at age t and $x_{i,j}$ the input (e.g., calories or protein) at age j. Then, the height and weight production functions are given by:

$$\hbar_{i,t} = \alpha\mu_i + \sum_{j=1}^{t} \beta_{t-j} x_{i,j} + \epsilon_{i,t}^{\hbar} \ (1)$$

$$w_{i,t} = \sigma\mu_i + \sum_{j=1}^{t} \delta_{t-j} x_{i,j} + \epsilon_{i,t}^{w} \ (2)$$

Where μ_i is an individual (genetic) fixed effect and $\epsilon_{i,t}^{h}$and $\epsilon_{i,t}^{w}$ are error terms that represent measurement error or omitted variables. We are assuming that the whole history of inputs enters into both equations.

These two equations are complicated to estimate since they include fixed effects and the whole history of inputs. In the case where inputs are endogenous and correlated with the individual fixed effect, it would be necessary to use instrumental variables for the whole history of inputs. Instead of directly estimating these two equations, we make two assumptions that allow us to obtain less demanding specifications, in terms of instruments. The assumptions are:

Assumption 1. The effect of past inputs follows a decreasing (or increasing) pattern at a constant rate for each period. That is: $\beta_{t-j} = \gamma\beta_{t-j-1}$ and $\delta_{t-j} = \gamma\delta_{t-j-1}$. The increasing or decreasing nature of the constant rate depends on γ. This assumption is restrictive, but less so than the assumption made, for example, by Griffen (2013), which assumes $\gamma = 1$.

Assumption 2. The coefficients of the inputs in the weight function are similar to the coefficients in the height function, up to a multiplicative constant $\delta_{t-1-j} = \frac{1+\sigma}{\alpha}\beta_{t-1-j}$.

We take differences in height and obtain the following equation:

$$\Delta h_{i,t} = \beta_0 x_{i,t} + \sum_{j=1}^{t-1}(\beta_{t-j} - \beta_{t-1-j})x_{i,j} + \epsilon_{i,t}^{h} - \epsilon_{i,t-1}^{h}$$

Now, under the first assumption $\beta_{t-j} = \gamma\beta_{t-j-1}$, then:

$$\Delta h_{i,t} = \beta_0 x_{i,t} + (\gamma - 1)\sum_{j=1}^{t-1}\beta_{t-1-j}x_{i,j} + \epsilon_{i,t}^{h} - \epsilon_{i,t-1}^{h}$$

Next, consider the following difference from equations (1) and (2):

$$\alpha w_{i,t-1} - \sigma h_{i,t-1} = \sum_{j=1}^{t-1}(\alpha\delta_{t-1-j} - \sigma\beta_{t-1-j})x_{i,j} + \alpha\epsilon_{i,t-1}^{w} - \sigma\epsilon_{i,t-1}^{h}$$

Now, under the second assumption that: $\delta_{t-1-j} = \frac{1+\sigma}{\alpha}\beta_{t-1-j}$, then:

$$\alpha w_{i,t-1} - \sigma h_{i,t-1} + \sigma \epsilon_{i,t-1}^{h} - \alpha \epsilon_{i,t-1}^{w} = \sum_{j=1}^{t-1} \beta_{t-1-j} x_{i,j}$$

Consequently,

$$\Delta h_{i,t} = \beta_0 x_{i,t} + \frac{\alpha}{(\gamma-1)} w_{i,t-1} - \frac{\sigma}{(\gamma-1)} h_{i,t-1} + \omega_{i,t}^{\Delta h} \quad (3)$$

where $\omega_{i,t}^{\Delta h} = \epsilon_{i,t}^{h} + \left(\frac{\sigma}{\gamma-1} - 1\right) \epsilon_{i,t-1}^{h} - \frac{\alpha}{\gamma-1} \epsilon_{i,t-1}^{w}$.

This equation indicates that the difference in height can be expressed as a function of current inputs, past height and growth and an error term that involves current (*t*) and past (*t-1*) shocks. In this specification, only current but not past inputs enters into the equations. Note, however, the history of the past inputs is considered through past height and weight.

We proceed in a similar fashion for the weight equation. Let's consider the change in weight:

$$\Delta w_{i,t} = \delta_0 x_{i,t} + \sum_{j=1}^{t-1} \left(\delta_{t-j} - \delta_{t-1-j}\right) x_{i,j} + \epsilon_{i,t}^{w} - \epsilon_{i,t-1}^{w}$$

Again, under the first assumption $\delta_{t-j} = \gamma \delta_{t-j-1}$, then:

$$\Delta w_{i,t} = \delta_0 x_{i,t} + (\gamma - 1) \sum_{j=1}^{t-1} \delta_{t-1-j} x_{i,j} + \epsilon_{i,t}^{w} - \epsilon_{i,t-1}^{w}$$

Now, using the second assumption, $\delta_{t-1-j} = \frac{1+\sigma}{\alpha} \beta_{t-1-j}$, we obtain:

$$\Delta w_{i,t} = \delta_0 x_{i,t} + \frac{(\gamma - 1)(1 + \sigma)}{\alpha} \sum_{j=1}^{t-1} \beta_{t-1-j} x_{i,j} + \epsilon_{i,t}^{w} - \epsilon_{i,t-1}^{w}$$

which then implies that:

$$\Delta w_{i,t} = \delta_0 x_{i,t} + (\gamma - 1)(1 + \sigma) w_{i,t-1} - \frac{\sigma(\gamma-1)(1+\sigma)}{\alpha} h_{i,t-1} + \omega_{i,t}^{\Delta w} \quad (4)$$

where $\omega_{i,t}^{\Delta w} = \epsilon_{i,t}^{w} + \left[\frac{\sigma(\gamma-1)(1+\sigma)}{\alpha} - 1\right] \epsilon_{i,t-1}^{h} - (\gamma - 1)(1 + \sigma) \epsilon_{i,t-1}^{w}$.

As in the case of the change in height equation, the change in weight equation depends on current inputs, past weight and height, and an error term that includes current and past shocks.

2.2. Estimation

In order to estimate the change in height (equation 3) and change in weight (equation 4), we need to overcome endogeneity problems. First, current inputs are correlated with the error term if we assume that the household responds to past shocks, either in the original height or weight equations (equations 1 and 2), or to current shocks. Second, past height and weight are correlated to the error term by construction.

The set of instruments we use differ by country. For the Philippines we use prices of different types of food, current and lagged, particularly prices of dried fish, eggs, and tomatoes. These prices were collected for each round and each Barangay[1] in Cebu. We expect these prices to affect the relative demand of foods rich in protein and calories. We include past weight and height measures, $w_{i,t-2}$ and $h_{i,t-2}$ as instruments, which are not correlated with the error term in equations (3) and (4).

In the case of Guatemala, we use whether the village was part of the randomized control trial that took place from 1969 to 1977 (more details on the intervention are presented in the following section). We include a dummy variable that indicates if the village had a feeding center that delivered a high protein supplement, compared to a food supplement that did not include protein. We also include an interaction term between the distance to the feeding center and the presence of a high-protein food supplement in the village. We include annual prices of eggs, chicken, pork, and beef. The main disadvantage of the instrumental price variables for Guatemala is that they correspond to country-level annual prices because prices at the village level for shorter periods are not available.

The instrumental variables approach requires that the error term of equations (3) and (4) are not correlated with the instruments. This assumption could fail if error terms in equations (1) and (2) are correlated over time. Additionally, we require that potential omitted inputs in the production function are not correlated with the error term in equations (3) and (4). When possible, we

[1] A Barangay is the smallest administrative division in the Philippines.

perform an over-identification test to provide evidence for these assumptions. We estimate the relations using GMM for exactly identified and Limited Information Maximum Likelihood for over-identified models.

3. Data

We estimate height and weight production functions for children in Guatemala and the Philippines based on databases containing unique information about children's weight, height, and calorie and protein consumption. There is in addition information on breastfeeding and diarrhea. In this section we describe the data collection process for each country.

3.1. Guatemala

The Guatemalan data is from a study conducted by The Institute of Nutrition of Central America and Panama (INCAP), which started a nutritional supplementation trial in 1969. Four villages from eastern Guatemala were selected, one pair of villages that were relatively large (900 residents each) and one pair that were smaller (500 residents each). The villages were similar in child nutritional status, measured as height at three years of age (Habitch, Martorell and Rivera 1995). Over 50% of children lacked proper nutrition, measured as height-for-age z-scores less than -3 (severely stunted). The intervention consisted of randomly assigning nutritional supplements. One large and one small village were selected to receive a high protein drink called Atole, and the other two were selected to receive an alternative supplement called, Fresco. Each serving of Atole (180 ml) contained 11.5 grams of protein and had 163 kcal. Atole tasted sweet and was served hot. Fresco had no protein and each serving (180 ml) had 59 kcal. The main hypothesis of the project was that better nutrition would accelerate mental development. At the same time, it was expected that the nutritional supplement would also have an effect on physical growth (Habitch, Martorell and Rivera 1995). The intervention started on January 1st, 1969 and lasted until February 28th, 1977, but data collection took place until September 1977 (Islam and Hoddinott 2009). The nutritional supplements were distributed in feeding centers located centrally in each village. The centers were open twice a day, two to three hours in the mid-morning and two to three hours in the mid-afternoon. All village members had access to the feeding centers.

Information on supplement intake was collected daily for all pregnant women and children up to seven years-old. At the same time, home diet information was collected monthly for children between 0 and 12 months, every 3 months for children between 15 and 36 months, every 6 months for children between 42 to 60 months, and yearly for children between 72 and 64 months-old The home diet data corresponds to a 24-hour recall in large villages and a 72-hour recall in small villages. From the home diet data collection is possible to calculate the protein and calorie intake, which we use in our estimations. Breastfeeding information was collected every month. Also, retrospective information was collected about the start and end of several symptoms and diseases, such as fever, diarrhea, and long-term skin infections every fifteen days.

Anthropometric measures were collected in the following way: every three months for children 0 to 24 months-old, every six months for those 24 to 48 months–old, and yearly for those 48 to 72 months-old.

3.2. The Philippines

The Cebu Longitudinal Health and Nutritional Survey is an ongoing survey of more than 2,000 Filipino children born between May 1983 and April 1984 in 33 communities inside the Metropolitan Cebu area. During the first two years of each child's life, researchers from the University of North Carolina in collaboration with the Office of Population Studies in Cebu collected data every two months. This data included the child's height, weight, past 24-hour food intake, and recent history of sickness. The 24-hour food intake history recorded the types and amounts of food eaten in the past day. For children who were breastfed, the survey collected the frequency and length of breast-milk intake time for each child. Total protein and caloric intake information were calculated by summing up the nutritional content for each type of food. It is difficult to impute nutritional value from breast-milk time given heterogeneity across mothers; hence, breast milk time was not included in the nutritional intake calculations. The survey gave particular emphasis to diarrhea. We know if a child had diarrhea in the past 24 hours, and if food consumption was adjusted in response to diarrhea. We also know the length of the current episode of diarrhea. For children who did not have diarrhea in the past 24 hours, we also know if and for how long they had diarrhea during the previous seven days.

3.3. Variables used in the estimation

The variables included in the estimation are height, weight, protein and calorie intake, breastfeeding, and the non-presence of diarrhea. Growth for both height and weight is measured as the difference between two time periods. Since we have access to the exact measurement date, we can calculate exactly how many days pass between measurements. This information is relevant because, despite the fact that children were supposed to be measured every two or three months, the exact lengths of time between measurements differed. Since children experience high growth during the first two years of life and differences in a few days can imply big differences in growth, these time gaps have to be accounted for.

For Guatemala, measurement occurred, on average, every three months and for the Philippines, every two months. In some cases, a two or three month measurement was not made. We observe some height and weight growth periods of four months or more for the Philippines and six months or more for Guatemala. Those longer-than-expected growth periods are included in the estimation, but adjusted for the number of days that elapsed between measurements.

Protein and calorie consumption are the average of the last two measurements. Ideally, we would like to have information about the total intakes during the whole period between the measurements; we approximate this measure by using the beginning and end points of the measurement, which also should decrease measurement error and intake endogeneity. We multiply the average intake for the number of days between measurements and then use the approximate total protein and caloric intake during the whole growth period. Additionally, we consider the amount of calories net of the calories that come from the protein intake, since each gram of protein contains 4 calories; net calories are total calories minus four times the protein intake.

In the case of breastfeeding, with the objective of using a consistent variable, we create a dummy variable to indicate whether the child was breastfed in the past month. For Guatemala, this is the only information available, but the Philippines has more detailed information (number of minutes of breastfeeding), but we opted to summarize it as a dummy variable for consistency.

Disease, in the form of diarrhea, is also included in the estimation. We selected diarrhea since it has been considered as a major contributor to stunting and wasting and child mortality, and is available in both data sets. There are important differences in how each project collected data about diarrhea. In the case of Cebu, it is possible to construct the number of days with diarrhea in the past seven days (prior to the height and weight measurement). In the case of Guatemala, information was collected every fifteen days, so it is possible to construct the number of days with diarrhea during for the complete growth period. However, sometimes interviews did not occur in the fifteen-day period, and for those cases no information was collected. For those children, we have a lower bound for the days with diarrhea between height/weight measurements. In the case of Guatemala, we calculated the ratio of the days with diarrhea to all observed days in a given growth period, and then multiplied this ratio of days with diarrhea by the number of days that passed during the height and weight measurement. This variable provides information on the total number of days a child suffered from diarrhea. Moreover, in the case where a child was consistently observed, it exactly measures the number of days with diarrhea. Meanwhile, in the case, a child skipped a fifteen-day check-up, we assume that the child had a similar outcome than the rest of period it was observed.

As mentioned, in the case of the Philippines, we only observe the seven days previous to the height and weight measurement, but from that we extrapolate what happened during the sixty-day interval. To do this, we estimated a count model for number of days with diarrhea for Guatemala, where information for the past fifteen days of a given two-month period was used as a regressor for the number of days with diarrhea for that two-month period. Then, using the parameter from the Guatemala count model, we created an approximate variable for the number of days with diarrhea in the last sixty days for the Philippines.

3.4. Descriptive statistics

The richness of the data from Guatemala and the Philippines allow us to compare nutritional intakes and anthropometric variables for children less than two years of age. In Table 1 we show the number of observations available for each data set. We restrict the sample to children without missing information for height, weight, protein and calorie consumption, number of days with diarrhea, and whether the child was breastfeed. The available Philippines-Cebu data ranges from 2,300 to 2,500 observations per age range. The Guatemala-INCAP data shows more variability because from 1969 to 1972 no information on home diet was collected for children between 0 and 12 months of age. At the same time, Table 1 shows how the number of observations changes when different sets of instruments are used. In general, the use of lags information on weight and height decreases the number of observations available in each country, especially Guatemala. In the Philippines, the use of prices as instruments has a higher impact on lowering the number of observations available, this occurs because prices are not always available for each community in every round. For Guatemala, the use of prices has the opposite effect, since they are annual prices available for all villages and could be used instead of lags of weight and height, they actually increase the number of observations available.

In Table 2 we observe that for the first two years of life, Filipino children were almost two centimeters taller than the Guatemalan children. For example, at 12 months of age, children from the Philippines were, on average, 70.7 cm tall, while their Guatemalan counterparts were 68.7 cm tall. At 24 months the average height was 79.1 in the Philippines and 77.5 in Guatemala. In terms of weight, Filipino children were modestly heavier: at 12 months, children from the Philippines weighed, on average, 8,000 grams and children in Guatemala weighed 7,800 grams.

Differences in height and weight could be due to genetic endowment and/or differences in inputs, the available data allows us to compare calorie and protein intakes between the children in both countries. The protein and calorie intakes are taken from the home diet information and do not consider breastfeeding[2]; however we can compare the percentages of children who were breastfed at different ages. Protein intake has greater differences by country; Tables 3a and 3b indicate that at 6 months, 92% of Filipino children consumed some protein while only 68% of Guatemalan children did. This is consistent with proteins being an important input in the production function of height and Filipino children being taller that their Guatemalan counterparts. In the case of calories, more than 90% of children of both countries consumed some calories at age 6 months. At 12 months, almost all of children had consumed non-breast

[2] For Guatemala, protein and calorie intakes are the sum of home diet and supplement diet information.

milk protein and calories. In terms of the amount of protein and calorie consumed, Tables 3a and 3b indicate that at 12 months Filipino children consumed more protein and calories than Guatemalan children. The differences were more than 16% for protein and 20% in the case of calories, however, those differences not only disappear, but favor Guatemalan children at 24 months, at which age Guatemalan children consumed 20% more calories and 18% more protein. The fact that protein and calorie intakes increase after the age of 12 months in Guatemala, is consistent with the catch-up in terms of height (though small) of Guatemalan children with respect to Filipino children. The objective of estimating production functions for height and weight is to investigate the mechanics of growth, such that these correlations can be translated into a causal model.

In the case of breastfeeding, some interesting differences can be observed. In general, Guatemalan children tend to be breastfed longer than Filipino children. Table 4a indicates that at 6 months-old, 99% of Guatemalan children are still breastfed, while that figure is 76% for the Philippines. These differences persist for the first two years of life.

Table 4b provides information about the prevalence of diarrhea counting the number of days without diarrhea. In Philippines, diarrhea is higher at 8, 14, and 20 months of age.

One important variable to be considered is the number of days elapsed between height and weight measurements, we observe that on average, the time elapsed in the Philippines is 2.1 months, which is influenced by outliers which skip one measurement. Thus their age-gap could be four months instead of two. Similarly, for Guatemala, the mean age-gap is higher than three months.

The descriptive statistics shown in this section shows the breadth of the data. Next we present the results of estimating the production functions presented in Section 2.

4. Results

In Section 2 we discuss the assumptions that are needed to control for potential endogeneity problems when estimating the production function for height and weight. In this section of the paper we present the results for the Philippines and Guatemala using instrumental variable estimation to address the endogeneity problems.

Additional to the endogeneity problems, protein and calories exhibit high correlations levels (close to 0.8 for all age levels) implying high standard errors in the estimation, a problem that is even more difficult to solve with instrumental variables. To evaluate the effect of the high correlation between protein and calories, we estimate the production functions including only proteins, only net calories and compare the estimates to specification when both protein and net calories are included. For each specification we calculate the Cragg-Donald statistic for weak-instruments and when possible, we calculate the Hansen-J test for exogeneity of the instruments.

We estimate the production functions for all possible combinations of the instruments and to summarize results we present the results in graphs. In each set of graphs, the point estimate and its confidence interval is shown, in each figure we present two graphs, the graph on the left includes specifications if only one nutritional input was included (either protein or calories) and the graph on the right includes the specifications in which both protein and calories are included. Also we restrict the results to specifications with a Cragg-Donald statistic greater than 1.5 and a Hansen-J statistic greater than 0.1, so we consider instruments that are relatively strong and exogenous.

In general, we find that proteins have positive effects on height and weight, which are robust to different specifications. However calories do not show such a strong pattern with anthropometric measures. For instance, Figure 1 shows the protein coefficient for the height production function. If only protein was included in the estimation we observe that the coefficient is positive and mostly significant. Also for low values of the Cragg-Donald F-statistic, the coefficient for the Philippines is greater than the coefficient from Guatemala, however, but for higher F-statistics both coefficients are similar. In the case in which the specifications include protein and calories we observe that the coefficients remain positive, but less significant, which was expected given the high correlation between nutritional inputs and the lower value of the F-statistics that are observed. Nonetheless in many specifications proteins positively and significantly affect height growth.

In the case of calories we find that there more differences emerge by country and the inclusion of protein in the estimation affects importantly the results. The first graph of Figure 2 shows that for low levels of the Cragg-Donald F-statistic, calories seem to have a positive and significant effect on height growth in the Philippines, but no significant effect in Guatemala. For high levels of the

F-statistics, the coefficients are more similar, but mostly non-significant. The second graph in Figure 2 indicates that when proteins are included in the estimation, the coefficient on calories is mostly negative and non-significant, which suggests that calories may play a less important role on height growth as compared to protein.

The evidence of protein of being more consistently associated with height growth is also found for the weight production function. The first graph in Figure 5 indicates that protein has a positive and, for most of the specifications, positive effect on weight growth The second graph shows a similar pattern, even though the F-statistics are smaller when protein and calories are both included in the estimation. Figure 6 show that calories have no effect on weight, only in the specification with calories, for low values of the F-statistic and the Philippines, calories exhibit a positive and significant coefficient, however for high values of the F-statistic, calories have non-significant effect on weight growth, and the same result is found when proteins are included in the specification, as shown in the second graph of Figure 6.

The dynamics of height and weight are captured by the lags of height and weight. Figure 3 indicates that taller children tend to grow less in the next period. This finding is consistent for both countries and for specifications that include only protein or calories and protein and calories. The estimates also suggest that heavier children tend to growth more in the next period, as shown in Figure 4, the coefficient on lagged weight is positive for both countries and for high values of the F-statistic. The results hold for specifications with protein or calories and protein and calories.

For the dynamics of the weight equation, a less consistent pattern emerges. Figure 7 shows the coefficient of lagged height in the weight growth equation. In general, taller children tend to gain less weight in the next period. However the parameters have high standard errors and when protein and calories both are included, lagged height is mostly non-significant. Figure 8 indicates that negative non-significant effect of lagged weight on weight gain is found for low F-statistics in Guatemala However for higher F-statistics, the effect is positive and non-significant for both countries. When calories and proteins are included in the equations, weight in the previous period has no significant effect on changes in weight.

Next, we analyze two sets of preferred estimates for each country. Table 5 shows the specifications for Guatemala and Table 6 for the Philippines. Each table has two parts, part A is for the height production function and part B for the weight production function. Six columns are presented in each table, the first two are the specifications that include protein and calories, columns 3 and 4 are for the specifications that include only protein and columns 5 and 6 are for the specifications that include only calories. Finally, a test of the joint significance of proteins and calories is made for columns one and two.

Form Table 5, part A, we observe that the instruments present high F-statistics for the first stage, however the Cragg-Donald statistic varies between 3 and 9. Also, the instruments pass the test for under-identification (Anderson). However the instruments fail the Hansen endogeneity test in columns five and six. As discussed, due to the high correlation between calories and proteins, the specifications that include protein and calories tend to have lower Cragg-Donald statistics and higher standard errors. This could be in part affecting the coefficient on calories, which is marginally significant in column five and becomes non-significant when protein enters in the specification. On the other hand, proteins are significant in all specifications. The coefficient on proteins suggests that an increment of one standard deviation of protein at age 12 months (26 grams) increases height between 0.5 and 0.6 cm.

The pattern that proteins have a more robust relationship than calories with anthropometric measures can also be observed in Table 5, part B for the weight production function. The results for proteins indicate a one standard deviation increment in protein intake, at age 12 months, adds between 200 and 300 grams in children's weight

The results for the Philippines confirm that when proteins and calories are both included, parameters are more imprecisely estimated. For instance, in Table 6, part A and part B, the Cragg-Donald statistic is lower than two, and only proteins in column two for the height equation is statistically significant. Nonetheless, the test of joint significance favors the inclusion of protein and calories in the production function. From the estimates of the Philippines, we obtain that an increment of 26 grams of proteins (same effect we calculated for Guatemala) is associated with 1.2 to 2 centimeters in height growth and between 400 and 900 more grams in children's weight.

Summarizing, from tables 5 and 6 to graphs 1 to 8, we confirm a very stable pattern where protein positively affects height and weight for different specifications, however calories exhibit a less robust relationship, which is harder to estimate since proteins and calories are too highly correlated.

5. Discussion

Developing countries have experienced important improvements in health outcomes during the past decades, however malnutrition in children is remains an issue for both low and middle-income countries. This is especially important considering that differences in health and abilities that appear early in life have long lasting effects on productivity and general well being (Berhman and Deolalikar 1988); (Berhman and Rosenzweig 2004); (Cunha and Heckman 2008) and (Walker, et al. 2011)).

We propose a general framework to study the interaction of calorie and protein consumption and growth in small children, which translates into production functions of height and weight. The correct estimation of these production functions requires taking several common estimation problems into account, especially omitted variables and measurement error.

Preliminary calculations indicate that increasing proteins during the first two years of life has a positive effect on height and weight of the children in Guatemala and the Philippines. These results add to the evidence on the impacts of macro-nutrients on health of children. Using these calculations we can simulate several policy interventions that vary in intensity and timing during the first 24 first months of life and complement the findings and recommendations that *The Lancet* series (2008 and 2013) promote. We currently are exploring, for example, the impacts of parental beliefs regarding normal anthropometrics on their investments in their children. It is also possible to simulate the effects of subsidizing protein rich food and compare it effect to income transfer to parents, which are policies usually implemented in developing countries.

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Table 1: Number of Observations for Each Variable, including Zero values

	Philippines					Guatemala			
	basic	basic+ L1	basic+ L12	pEgFhTm	pEFT+ L1	basic	basic+ L1	basic+ L12	pEgCkPgBf+ L1
2mths									
3mths						293	12	12	116
4mths	2555	2554		868	6				
6mths	2492	2489	2486	1079	600	312	292	1	796
8mths	2472	2470	2449	1143	781				
9mths						311	298	272	849
10mths	2441	2439	2437	1133	801				
12mths	2430	2429	2429	1122	782	327	325	312	854
14mths	2406	2406	2405	1123	794				
15mths						700	696	683	864
16mths	2388	2385	2384	1076	787				
18mths	2380	2380	2380	1069	783	712	704	695	857
20mths	2379	2378	2377	1058	752				
21mths						707	701	696	839
22mths	2382	2376	2376	1019	736				
24mths	2398	2394	2394	967	716	693	690	683	824

basic = Number of observations with Height and weight, average calorie and protein, and Milk and Diarrhea
basic+L1 = Number of observations with Height and weight, average calorie and protein, and Milk and Diarrhea, lag height and lag weight
basic+L12 = Number of observations with Height and weight, average calorie and protein, Milk and Diarrhea, lag 1 height and lag weight, and lag 2 height and weight
pEgFhTm = Observations with Prices of Egg, Fish, and Tomato for Cebu
pEFT+L1 = Observations with Prices of Egg, Fish, and Tomato for Cebu + Lag 1 prices
pEgCkPgBf+L1 = Observations with Prices of Egg, Chicken, Pig and Beef for Guatemala all Lag 1

Table 2: Height and Weight

	Height				Weight			
	Philippines		Guatemala		Philippines		Guatemala	
	mean	sd	mean	sd	mean	sd	mean	sd
2mths	56.3	2.4			4.9	0.7		
3mths			57.3	2.5			5.4	0.8
4mths	61.0	2.5			6.1	0.8		
6mths	64.3	2.6	62.7	2.5	6.9	0.9	6.8	1.0
8mths	66.8	2.7			7.3	1.0		
9mths			65.9	2.7			7.4	1.0
10mths	68.9	2.8			7.6	1.0		
12mths	70.7	3.0	68.7	3.0	8.0	1.1	7.8	1.1
14mths	72.3	3.1			8.2	1.1		
15mths			71.0	3.2			8.3	1.1
16mths	73.7	3.3			8.5	1.1		
18mths	75.1	3.4	73.2	3.4	8.8	1.1	8.7	1.1
20mths	76.5	3.5			9.1	1.2		
21mths			75.4	3.5			9.2	1.1
22mths	77.7	3.6			9.4	1.2		
24mths	79.1	3.7	77.5	3.6	9.8	1.2	9.7	1.2

Weight in Kilogram
Height in Centimeters
Sd: standard deviation

Table 3a: Protein consumption

	Philippines			Guatemala		
	Not Including zero values mean(sd)	Including zero values mean(sd)	Share >0 mean(sd)	Not Including zero values mean(sd)	Including zero values mean(sd)	Share >0 mean(sd)
2mths	6.78	2.68	0.39			
	(6.25)	(5.14)				
3mths				4.63	2.68	0.58
				(4.94)	(4.40)	
4mths	5.72	3.50	0.61			
	(6.45)	(5.76)				
6mths	5.97	5.52	0.92	5.81	3.95	0.68
	(7.61)	(7.48)		(5.97)	(5.62)	
8mths	7.74	7.69	0.99			
	(9.00)	(8.99)				
9mths				7.21	6.33	0.88
				(6.85)	(6.84)	
10mths	9.35	9.34	1.00			
	(10.09)	(10.09)				
12mths	11.15	11.15	1.00	9.83	9.59	0.98
	(10.51)	(10.51)		(7.72)	(7.77)	
14mths	13.56	13.56	1.00			
	(11.65)	(11.65)				
15mths				15.54	15.52	1.00
				(9.42)	(9.43)	
16mths	15.36	15.36	1.00			
	(12.17)	(12.17)				
18mths	16.71	16.71	1.00	18.92	18.92	1.00
	(12.31)	(12.31)		(9.48)	(9.48)	
20mths	18.24	18.24	1.00			
	(12.66)	(12.67)				
21mths				22.27	22.27	1.00
				(10.24)	(10.24)	
22mths	19.62	19.62	1.00			
	(12.75)	(12.75)				
24mths	20.87	20.87	1.00	24.97	24.97	1.00
	(13.10)	(13.10)		(10.48)	(10.48)	

Calorie and Protein intake are for the past 24 or 72 hours
Sd: standard deviation

Table 3b: Calorie consumption

	Philippines			Guatemala		
	Not Including zero values mean(sd)	Including zero values mean(sd)	Share >0 mean(sd)	Not Including zero values mean(sd)	Including zero values mean(sd)	Share >0 mean(sd)
2mths	182.44	90.97	0.50			
	(188.62)	(161.43)				
3mths				87.52	71.74	0.82
				(129.78)	(122.20)	
4mths	169.59	115.22	0.68			
	(193.32)	(177.91)				
6mths	193.43	180.30	0.93	118.15	107.17	0.91
	(223.34)	(221.05)		(148.86)	(145.85)	
8mths	253.41	251.88	0.99			
	(245.64)	(245.68)				
9mths				188.77	185.13	0.98
				(176.36)	(176.57)	
10mths	309.25	308.87	1.00			
	(262.16)	(262.23)				
12mths	359.68	359.53	1.00	292.83	291.93	1.00
	(273.71)	(273.75)		(207.45)	(207.76)	
14mths	423.52	423.52	1.00			
	(285.26)	(285.26)				
15mths				481.35	481.35	1.00
				(251.14)	(251.14)	
16mths	480.37	480.37	1.00			
	(286.62)	(286.62)				
18mths	520.72	520.72	1.00	578.40	578.40	1.00
	(290.26)	(290.26)		(245.77)	(245.77)	
20mths	566.26	566.02	1.00			
	(301.86)	(302.02)				
21mths				676.94	676.94	1.00
				(265.42)	(265.42)	
22mths	603.67	603.67	1.00			
	(310.93)	(310.93)				
24mths	628.67	628.67	1.00	744.56	744.56	1.00
	(311.25)	(311.25)		(271.69)	(271.69)	

Calorie and Protein intake are for the past 24 or 72 hours
Sd: standard deviation
Share >0: Proportion with values greater than zero

Table 4a: Proportion with breast milk

	Philippines	Guatemala
2mths	0.84	
3mths		1.00
4mths	0.80	
6mths	0.76	0.99
8mths	0.72	
9mths		0.97
10mths	0.68	
12mths	0.62	0.91
14mths	0.53	
15mths		0.80
16mths	0.43	
18mths	0.34	0.58
20mths	0.26	
21mths		0.32
22mths	0.19	
24mths	0.14	0.17

0.1 = 10 Percent

Table 4b: Days with diarrhea and Age Gap

	Days Without Diarrhea				Age Gap			
	(1)		(2)		(3)		(4)	
	Philippines		Guatemala		Philippines		Guatemala	
	mean	sd	mean	sd	mean	sd	mean	sd
2mths								
3mths			91.0	0.4				
4mths	60.5	5.8			2.1	0.2		
6mths	60.0	6.7	91.0	0.2	2.1	0.2	3.0	0.2
8mths	58.4	12.2			2.1	0.4		
9mths			91.0	0.5			3.4	1.0
10mths	60.4	12.6			2.1	0.4		
12mths	59.7	13.0	92.0	0.2	2.1	0.5	3.4	1.1
14mths	57.8	11.9			2.1	0.7		
15mths			91.0	0.3			3.3	1.1
16mths	59.9	12.0			2.1	0.4		
18mths	60.4	11.8	91.0	0.2	2.1	0.4	3.1	0.7
20mths	57.4	13.1			2.1	0.4		
21mths			91.0	0.2			3.2	1.0
22mths	60.0	11.9			2.1	0.4		
24mths	60.7	10.9	92.0	0.1	2.1	0.4	3.3	1.1

Days Without Diarrhea is the number of days with Diarrhea since last measurement date
Cebu Diarrhea Days Imputed from 7 days info to Total days with Diarrhea since last measurement using Negative Binomial Count Model
Age-Gap is measurement gap between individual child's survey dates in months
Sd: standard deviation

Table 5, part A: Guatemala Preferred Estimates Height Production Function

	Prot and Cal		Protein		Calories	
Height	(1)	(2)	(3)	(4)	(5)	(6)
Lag 1 Height cm	-0.305***	-0.270***	-0.263***	-0.285***	-0.449***	-0.383***
	(-3.88)	(-4.56)	(-4.86)	(-6.45)	(-6.96)	(-8.43)
Lag 1 Weight kg	0.0212	0.153	-0.0837	0.201	1.065***	1.016***
	(0.05)	(0.45)	(-0.19)	(0.64)	(6.64)	(6.74)
protM*agegap	0.0227**	0.0192***	0.0249***	0.0181***		
	(2.35)	(2.79)	(2.70)	(2.90)		
calM*agegap	0.000315	-0.000106			0.000805*	0.000262
	(0.70)	(-0.39)			(1.65)	(1.04)
Days NoDiah	0.391***	0.304***	0.372***	0.308***	0.210**	0.147**
	(2.94)	(3.20)	(2.99)	(3.22)	(2.16)	(1.98)
Breast-Milk	0.629**	0.337*	0.494**	0.373**	0.462	0.162
	(2.07)	(1.81)	(2.29)	(2.27)	(1.56)	(0.92)
Age Gap	0.275	0.507***	0.389***	0.475***	0.364	0.613***
	(1.24)	(4.15)	(2.95)	(5.07)	(1.61)	(5.18)
Male	0.274*	0.227**	0.295**	0.216**	-0.0135	-0.0118
	(1.86)	(2.08)	(2.06)	(2.05)	(-0.19)	(-0.18)
Constant	-15.00	-10.31	-15.28	-9.975	3.517	5.435
	(-1.39)	(-1.27)	(-1.45)	(-1.24)	(0.54)	(0.97)
Hansen-J p-value		0.269	0.465	0.427	0.00826	0.0109
Anderson Under p	0.000345	0.00000675	0.000930	0.0000215	0.0000211	3.33e-11
Cragg-Donald Weak F	3.206	4.473	3.495	4.492	5.401	9.277
Prot+Cal jnt. p	0.0277	0.0133				
1S Hgt instr. jnt. F	56.14	37.64	56.14	37.64	56.14	37.64
1S Wgt instr. jnt. F	48.20	32.27	48.20	32.27	48.20	32.27
1S Prot instr. jnt. F	105.2	72.22	105.2	72.22		
1S Cal instr. jnt. F	23.39	21.12			23.39	21.12
1=atole treatment	instru	instru	instru	instru	instru	instru
Lag 1 Price Egg	instru	instru	instru	instru	instru	instru
Lag 1 Price Pig	instru	instru	instru	instru	instru	instru
Lag 1 Price Beef	instru	instru	instru	instru	instru	instru
Distance*atole		instru		instru		instru
Lag 1 Price Chicken		instru		instru		instru
N	3613	3445	3613	3445	3613	3445

protM*agegap: Protein intake multiplied by age gap
calM*agegap: Calorie intake multiplied by age gap
Days NoDiah: Days with no diarrhea
Breast-Milk: Dummy=1 if last month was breastfed
Male: Dummy=1 if male
Anderson Under p-value: P-value for Anderson test of under-identification
1S: First Stage F test of excluded instruments
t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5, part B: Guatemala Preferred Estimates Weight Production Function

	Prot and Cal	Protein		Calories	Prot and Cal	Protein
Weight	(7)	(8)	(9)	(10)	(11)	(12)
Lag 1 Height cm	-0.0454	-0.0507**	-0.0516**	-0.0653***	-0.128***	-0.108***
	(-1.47)	(-2.20)	(-2.31)	(-3.72)	(-3.84)	(-5.56)
Lag 1 Weight kg	-0.294	-0.144	-0.284	-0.101	0.330***	0.295***
	(-1.60)	(-1.09)	(-1.55)	(-0.79)	(5.05)	(4.63)
protM*agegap	0.0131***	0.00947***	0.0129***	0.00846***		
	(3.47)	(3.51)	(3.43)	(3.37)		
calM*agegap	-0.0000520	-0.000103			0.000191	0.0000655
	(-0.29)	(-0.97)			(0.68)	(0.59)
Days NoDiah Poi	0.211***	0.169***	0.216***	0.173***	0.0990**	0.0879***
	(4.03)	(4.54)	(4.21)	(4.52)	(2.04)	(2.78)
Breast-Milk	0.119	0.0250	0.144	0.0607	-0.00372	-0.0707
	(1.00)	(0.34)	(1.62)	(0.93)	(-0.02)	(-0.94)
Msr Age Gap	-0.0272	0.0483	-0.0482	0.0160	0.0421	0.106**
	(-0.31)	(1.01)	(-0.89)	(0.42)	(0.33)	(2.05)
Male	0.206***	0.158***	0.205***	0.149***	0.0339	0.0369
	(3.56)	(3.70)	(3.48)	(3.51)	(1.12)	(1.32)
Constant	-13.83***	-10.73***	-13.95***	-10.48***	-2.618	-2.678
	(-3.26)	(-3.39)	(-3.21)	(-3.24)	(-0.91)	(-1.13)
Hansen-J p		0.194	0.773	0.241	0.000141	0.00188
Ander Under p	0.000345	0.00000675	0.000930	0.0000215	0.0000211	3.33e-11
Cragg-Donald Weak F	3.206	4.473	3.495	4.492	5.401	9.277
Prot+Cal jnt. p	0.00215	0.00175				
1S Hgt instr. jnt. F	56.14	37.64	56.14	37.64	56.14	37.64
1S Wgt instr. jnt. F	48.20	32.27	48.20	32.27	48.20	32.27
1S Prot instr. jnt. F	105.2	72.22	105.2	72.22		
1S Cal instr. jnt. F	23.39	21.12			23.39	21.12
1=atole treatmt	instru	instru	instru	instru	instru	instru
Lag 1 prc Price Egg	instru	instru	instru	instru	instru	instru
Lag 1 prc Price Pig	instru	instru	instru	instru	instru	instru
Lag 1 prc Price Beef	instru	instru	instru	instru	instru	instru
Distance*atole		instru		instru		instru
Lag 1 prc Price Chicken		instru		instru		instru
N	3613	3445	3613	3445	3613	3445

protM*agegap: Protein intake multiplied by age gap
calM*agegap: Calorie intake multiplied by age gap
Days NoDiah: Days with no diarrhea
Breast-Milk: Dummy=1 if last month was breastfed
Male: Dummy=1 if male
Anderson Under p-value: P-value for Anderson test of under-identification
1S: First Stage F test of excluded instruments
t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6, part A: Philippines Preferred Estimates, Height Production Function

Height	Prot and Cal (1)	Protein (2)	Calories (3)	Prot and Cal (4)	Protein (5)	Cal (6)
Lag 1 Height cm	-0.178***	-0.180***	-0.183***	-0.187***	-0.203***	-0.230***
	(-7.13)	(-6.84)	(-18.46)	(-17.25)	(-11.45)	(-8.94)
Lag 1 Weight kg	0.224***	0.163***	0.224***	0.159***	0.233***	0.147**
	(4.69)	(2.94)	(4.72)	(2.91)	(4.82)	(2.07)
protM*agegap	0.0537	0.0761**	0.0454***	0.0668***		
	(1.15)	(2.03)	(2.87)	(3.94)		
calM*agegap	-0.000420	-0.000559			0.00212***	0.00376***
	(-0.19)	(-0.28)			(2.62)	(3.11)
Days NoDiah Poi	0.0138**	0.0101	0.0143***	0.0105	0.0177***	0.0139*
	(2.43)	(1.53)	(3.00)	(1.62)	(3.88)	(1.86)
Breast-Milk	1.057*	1.466**	1.150***	1.630***	1.533***	2.627***
	(1.73)	(2.11)	(3.03)	(4.07)	(2.73)	(3.18)
Msr Age Gap	-0.455	-0.577	-0.538**	-0.706***	-0.901**	-1.522***
	(-0.90)	(-1.11)	(-2.03)	(-2.75)	(-2.17)	(-2.79)
Male	0.0324	0.0160	0.0213	0.00162	-0.0333	-0.0938*
	(0.50)	(0.26)	(0.77)	(0.05)	(-0.86)	(-1.66)
Constant	11.08***	11.45***	11.34***	11.89***	12.49***	14.63***
	(6.65)	(6.44)	(12.28)	(13.32)	(8.70)	(7.42)
Hansen-J p		0.734	0.849	0.874	0.259	0.280
Anderson Under p	0.0207	0.0219	0.0000435	0.0000268	0.000286	0.00204
Cragg-Donald Weak F	1.338	1.606	5.026	4.399	4.081	2.814
Prot+Cal jnt. p	0.0169	0.000369				
1S Hgt instr. jnt. F	51340.2	27412.3	51340.2	27412.3	51340.2	27412.3
1S Wgt instr. jnt. F	27535.6	14782.3	27535.6	14782.3	27535.6	14782.3
1S Prot instr. jnt. F	264.4	141.2	264.4	141.2		
1S Cal instr. jnt. F	402.9	208.7			402.9	208.7
Lag 2 Height cm	instru	instru	instru	instru	instru	instru
Lag 2 Weight kg	instru	instru	instru	instru	instru	instru
prc Egg	instru	instru	instru	instru	instru	instru
prc Dried Fish	instru	instru	instru	instru	instru	instru
Lag 1 prc Dried Fish		instru		instru		instru
Lag 1 prc Egg		instru		instru		instru
N	13426	10830	13426	10830	13426	10830

protM*agegap: Protein intake multiplied by age gap
calM*agegap: Calorie intake multiplied by age gap
Days NoDiah: Days with no diarrhea
Breast-Milk: Dummy=1 if last month was breastfed
Male: Dummy=1 if male
Anderson Under p-value: P-value for Anderson test of under-identification
1S: First Stage F test of excluded instruments
t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6, part B: Philippines Preferred Estimates

	Prot and Cal	Protein	Cal	Prot and Cal	Protein	Cal
	(7)	(8)	(9)	(10)	(11)	(12)
Lag 1 Height cm	-0.0302**	-0.0408**	-0.0289***	-0.0280***	-0.0433***	-0.0498***
	(-2.57)	(-2.54)	(-6.16)	(-5.57)	(-4.86)	(-4.16)
Lag 1 Weight kg	-0.0883***	-0.110***	-0.0884***	-0.107***	-0.0853***	-0.111***
	(-3.93)	(-3.79)	(-3.92)	(-4.15)	(-3.51)	(-3.36)
protM*agegap	0.0269	0.0146	0.0294***	0.0343***		
	(1.22)	(0.66)	(3.92)	(4.18)		
calM*agegap	0.000125	0.00110			0.00143***	0.00190***
	(0.12)	(0.89)			(3.51)	(3.37)
Days NoDiah	0.00862***	0.00841**	0.00845***	0.00740**	0.0105***	0.00921***
	(3.24)	(2.54)	(3.73)	(2.53)	(4.60)	(2.70)
Breast-Milk	0.685**	1.049**	0.658***	0.758***	0.945***	1.249***
	(2.38)	(2.50)	(3.66)	(3.92)	(3.35)	(3.24)
Msr Age Gap	-0.629***	-0.816***	-0.605***	-0.578***	-0.868***	-0.983***
	(-2.65)	(-2.61)	(-4.82)	(-4.84)	(-4.15)	(-3.87)
Male	0.0372	0.00724	0.0405***	0.0352**	0.00324	-0.0128
	(1.23)	(0.20)	(3.09)	(2.23)	(0.17)	(-0.49)
Constant	2.761***	3.385***	2.684***	2.585***	3.522***	3.942***
	(3.53)	(3.14)	(6.12)	(6.06)	(4.88)	(4.29)
Hansen-J p-value		0.133	0.904	0.168	0.253	0.222
Anderson Under p-value	0.0207	0.0219	0.0000435	0.0000268	0.000286	0.00204
Cragg-Donald Weak F	1.338	1.606	5.026	4.399	4.081	2.814
Prot+Cal jnt. p	0.000431	0.000671				
1S Hgt instr. jnt. F	51340.2	27412.3	51340.2	27412.3	51340.2	27412.3
1S Wgt instr. jnt. F	27535.6	14782.3	27535.6	14782.3	27535.6	14782.3
1S Prot instr. jnt. F	264.4	141.2	264.4	141.2		
1S Cal instr. jnt. F	402.9	208.7			402.9	208.7
Lag 2 Height cm	instru	instru	instru	instru	instru	instru
Lag 2 Weight kg	instru	instru	instru	instru	instru	instru
Price Egg	instru	instru	instru	instru	instru	instru
Price Dried Fish	instru	instru	instru	instru	instru	instru
Lag 1 Price Dried Fish		instru		instru		instru
Lag 1 Price Egg		instru		instru		instru
N	13426	10830	13426	10830	13426	10830

protM*agegap: Protein intake multiplied by age gap
calM*agegap: Calorie intake multiplied by age gap
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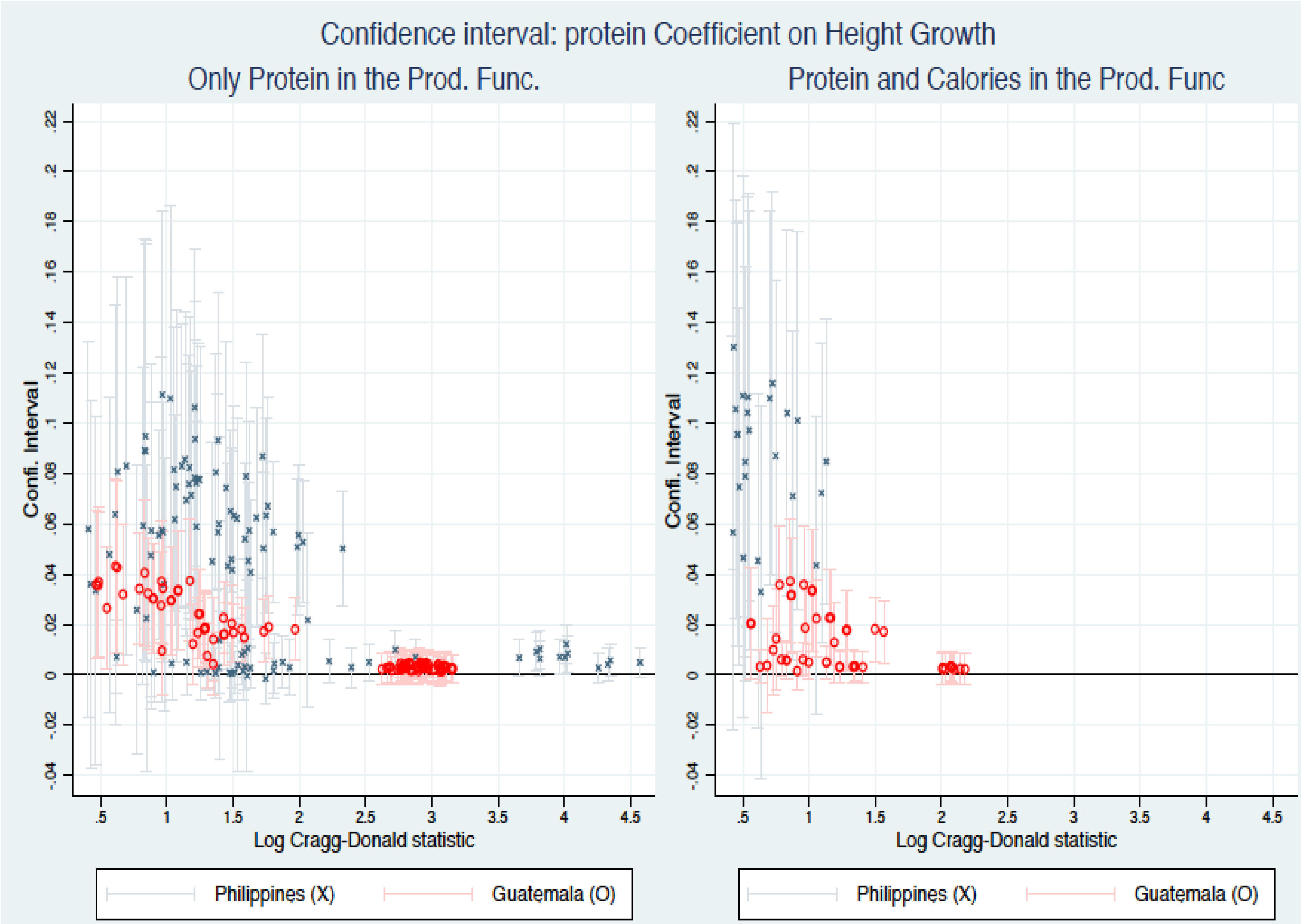
Breast-Milk: Dummy=1 if last month was breastfed
Male: Dummy=1 if male
Anderson Under p-value: P-value for Anderson test of under-identification
1S: First Stage F test of excluded instruments
t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Protein Coefficient and Confidence Interval – Height Production Function



1: Includes only when Cragg-Donald > 1.5 and Hansen-J > .1

2: All regression include binary milk variable, continuous Diarrhea variable, gender, and gap in age across measurement as covariates

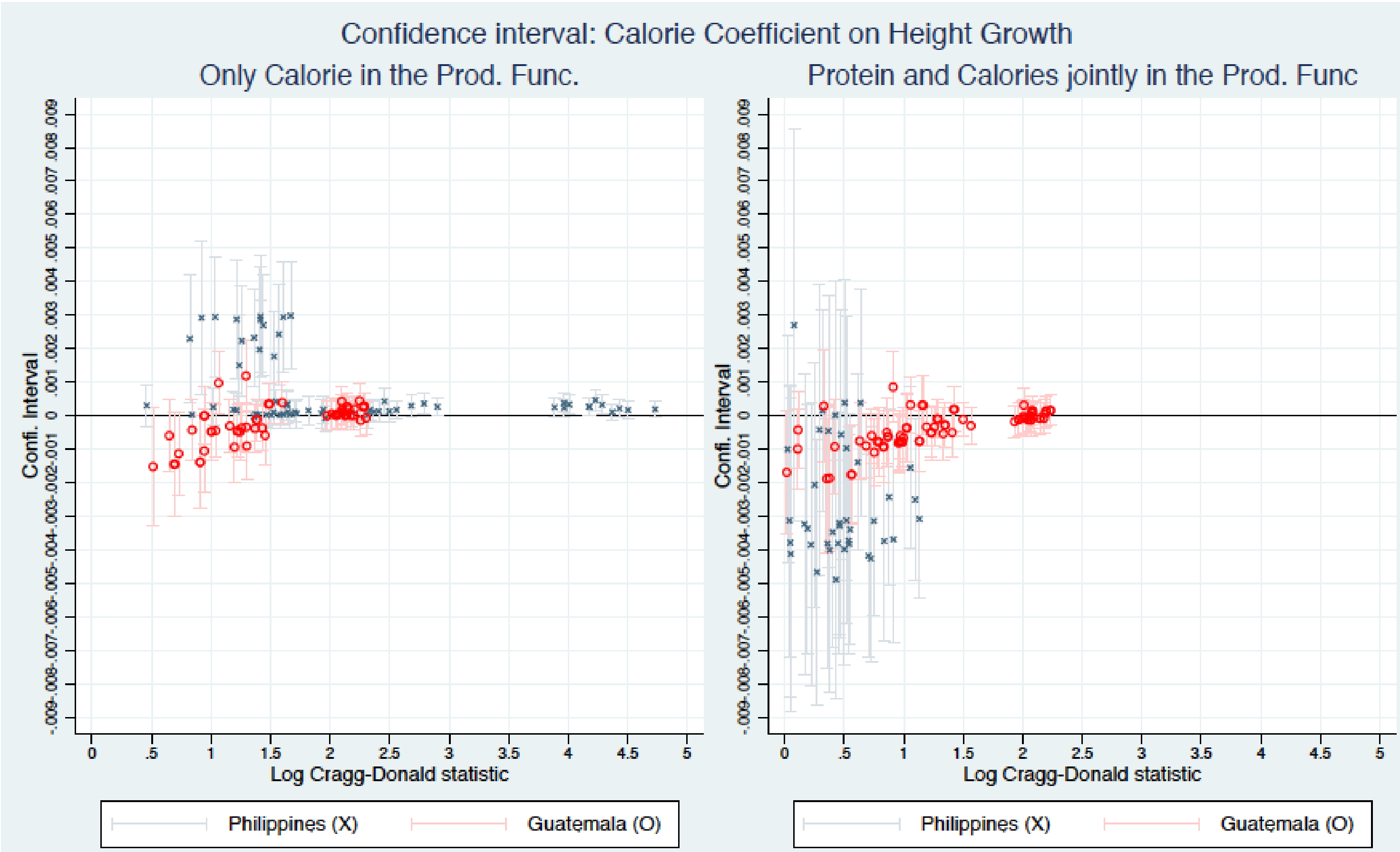
3: All regression include Lag 1 Height and lag 1 Weight as endogeneous variables

4: Instruments for Guatemala Include: combinations of 6 different lag annual prices, atole, atole*distance, Lag2 Height, Lag2 Weight

5: Instruments for Cebu Include: combinations of 3 different current and lag monthly prices, Lag2 Height, Lag2 Weight

6: Number of Instruments: 27% 4 instru., 38% 5 instru., 27% 6 instru. 6% 7 instru.

Figure 2: Calorie Coefficient and Confidence Interval – Height Production Function



1: Includes only when Cragg-Donald > 1 and Hansen-J > .05

2: All regression include binary milk variable, continuous Diarrhea variable, gender, and gap in age across measurement as covariates

3: All regression include Lag 1 Height and lag 1 Weight as endogeneous variables

4: Instruments for Guatemala Include: combinations of 6 different lag annual prices, atole, atole*distance, Lag2 Height, Lag2 Weight

5: Instruments for Cebu Include: combinations of 3 different current and lag monthly prices, Lag2 Height, Lag2 Weight

6: Number of Instruments: 27% 4 instru., 38% 5 instru., 27% 6 instru. 6% 7 instru.

Figure 3: Lag Height Coefficient and Confidence Interval – Height Production Function

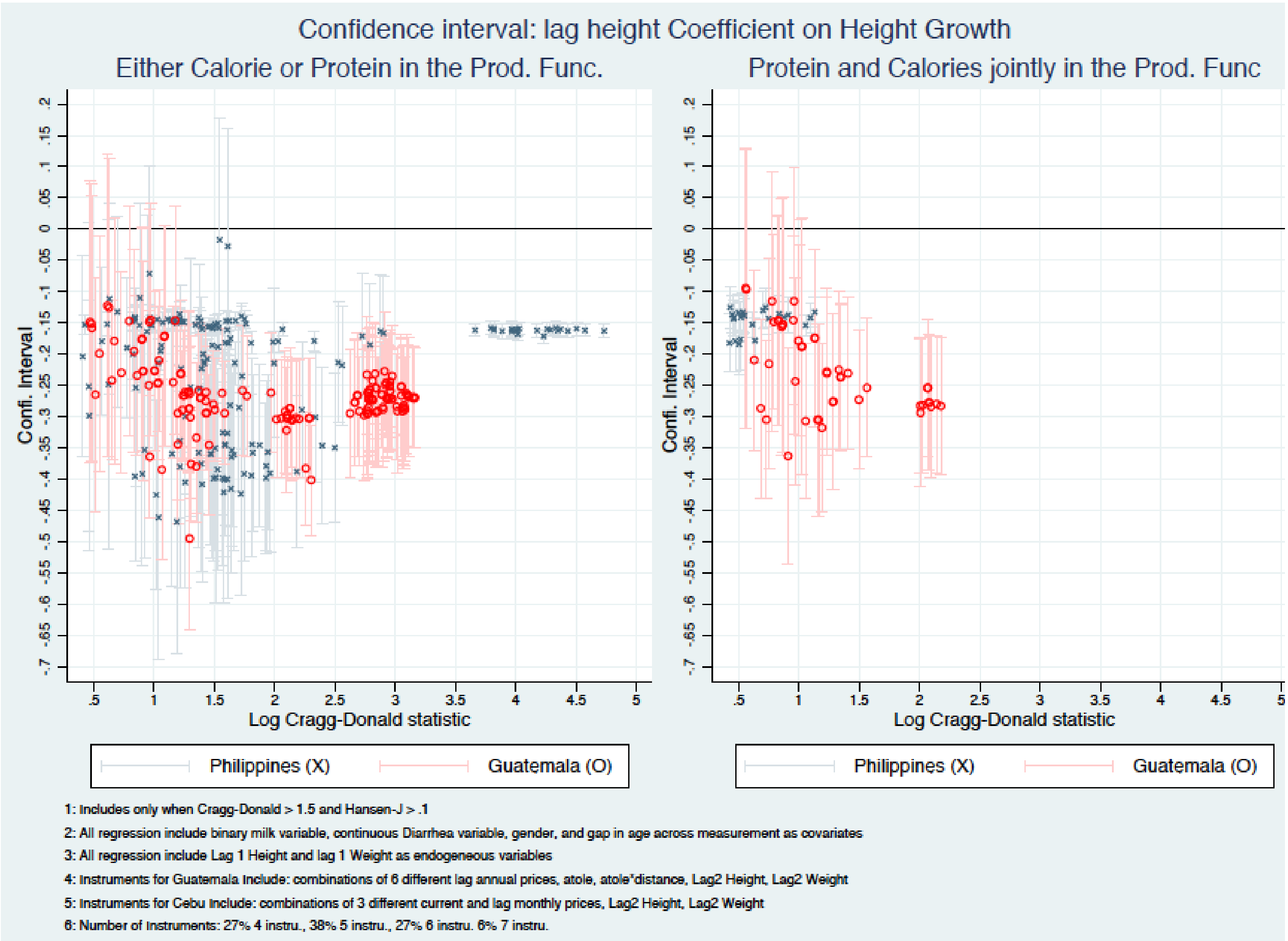


Figure 4: Lag Weight Coefficient and Confidence Interval – Height Production Function

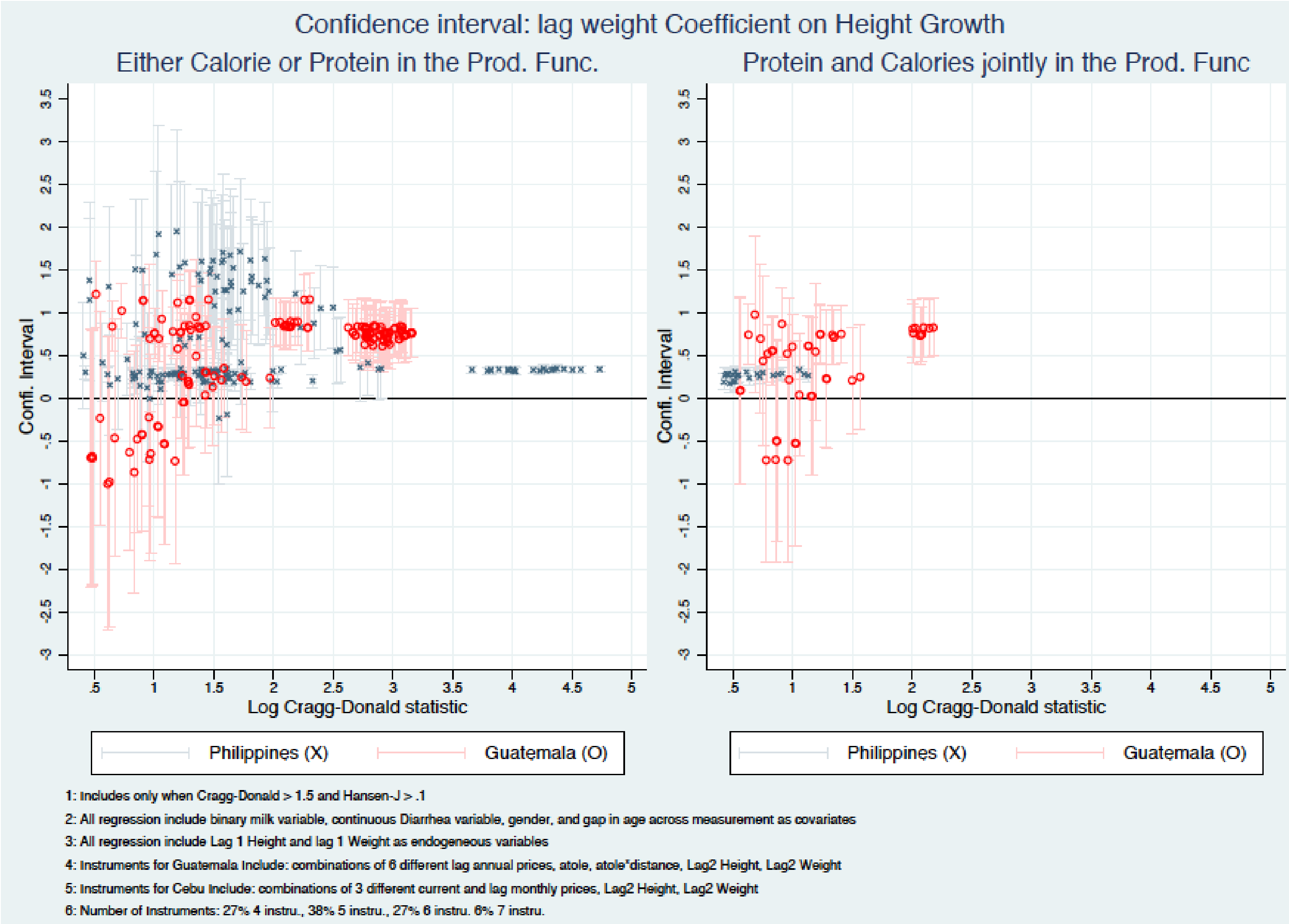
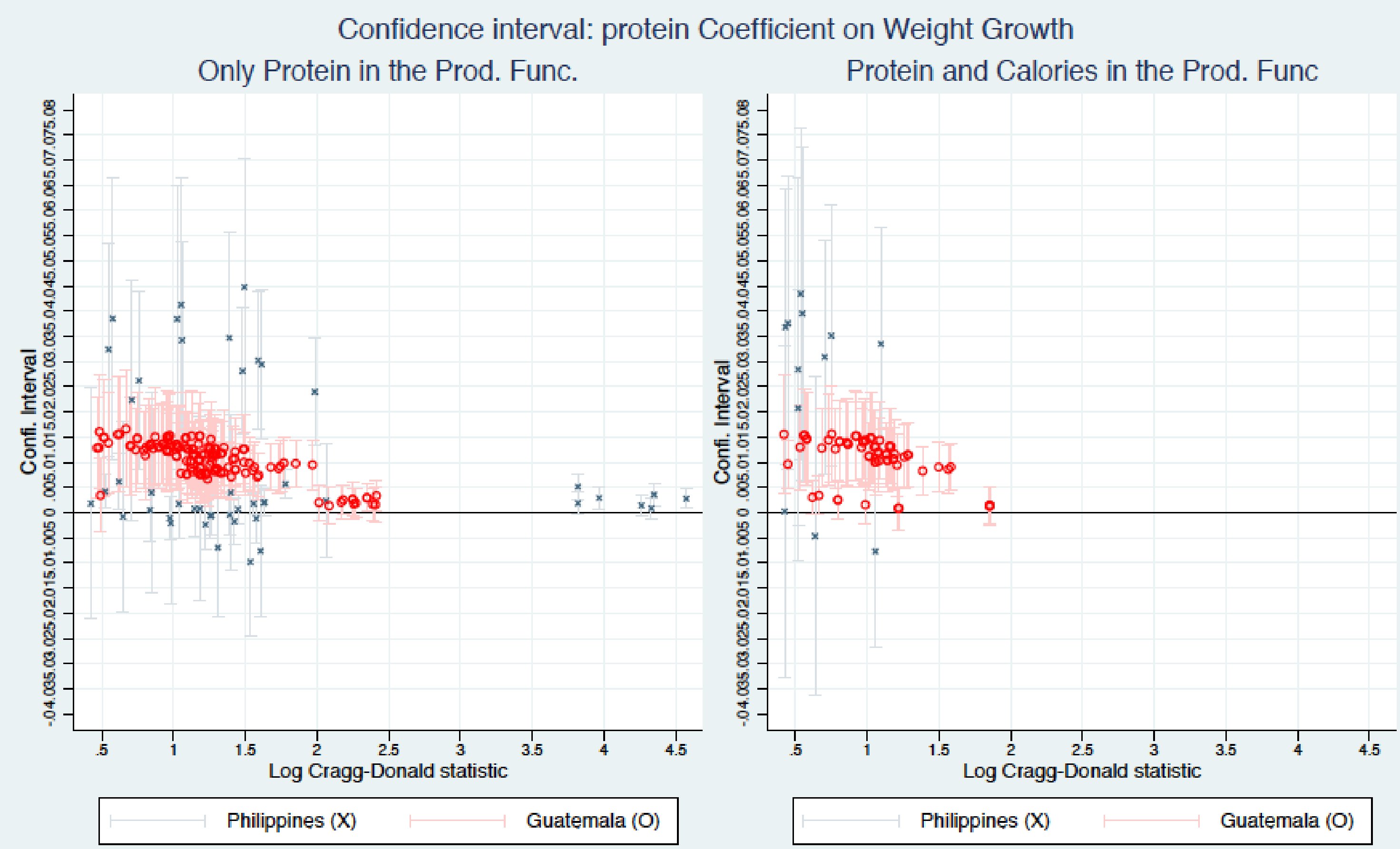


Figure 5: Protein Coefficient and Confidence Interval – Weight Production Function



1: Includes only when Cragg-Donald > 1.5 and Hansen-J > .1

2: All regression include binary milk variable, continuous Diarrhea variable, gender, and gap in age across measurement as covariates

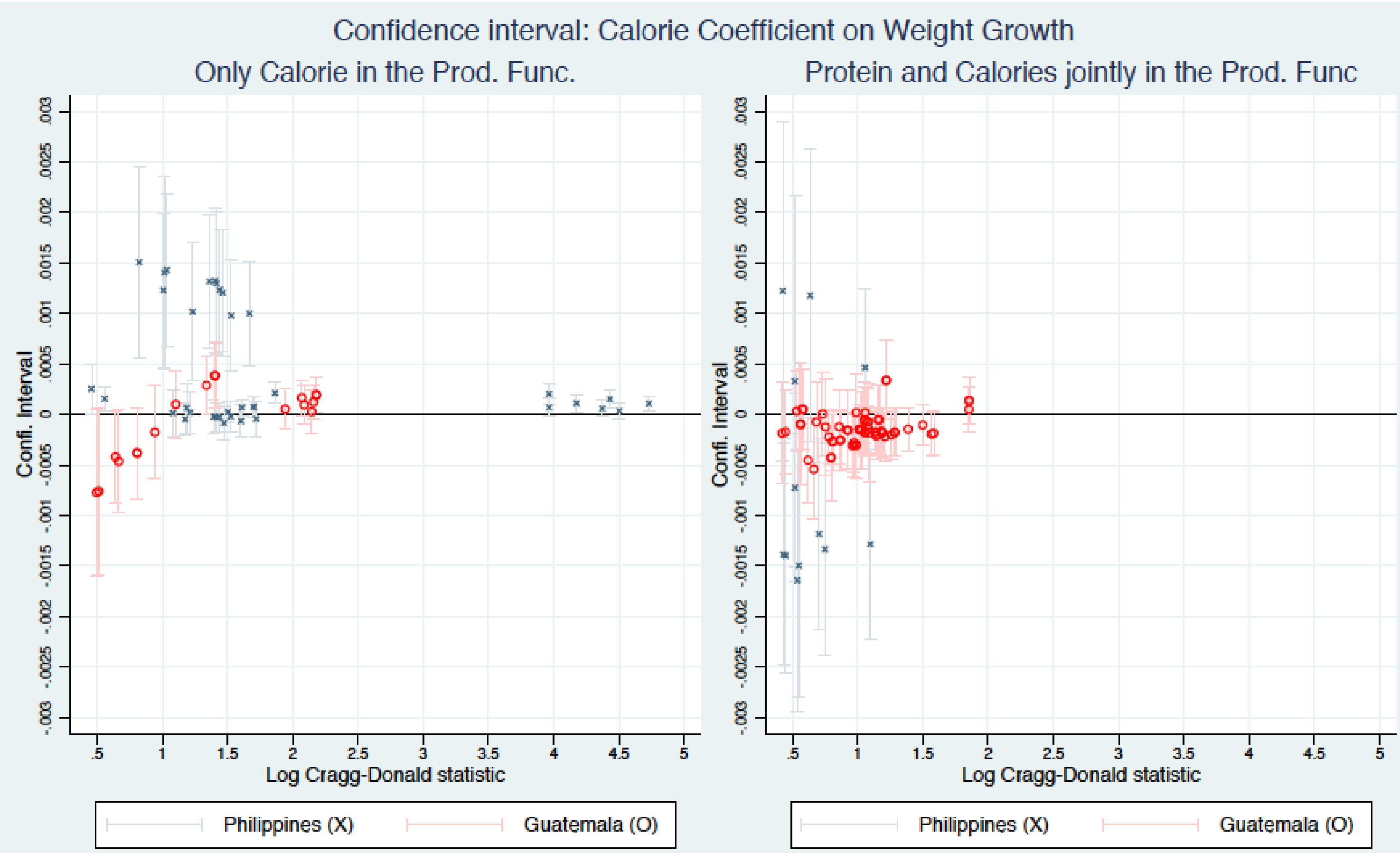
3: All regression include Lag 1 Height and lag 1 Weight as endogeneous variables

4: Instruments for Guatemala Include: combinations of 6 different lag annual prices, atole, atole*distance, Lag2 Height, Lag2 Weight

5: Instruments for Cebu Include: combinations of 3 different current and lag monthly prices, Lag2 Height, Lag2 Weight

6: Number of Instruments: 27% 4 instru., 38% 5 instru., 27% 6 instru. 6% 7 instru.

Figure 6: Calorie Coefficient and Confidence Interval – Weight Production Function



1: Includes only when Cragg-Donald > 1.5 and Hansen-J > .1

2: All regression include binary milk variable, continuous Diarrhea variable, gender, and gap in age across measurement as covariates

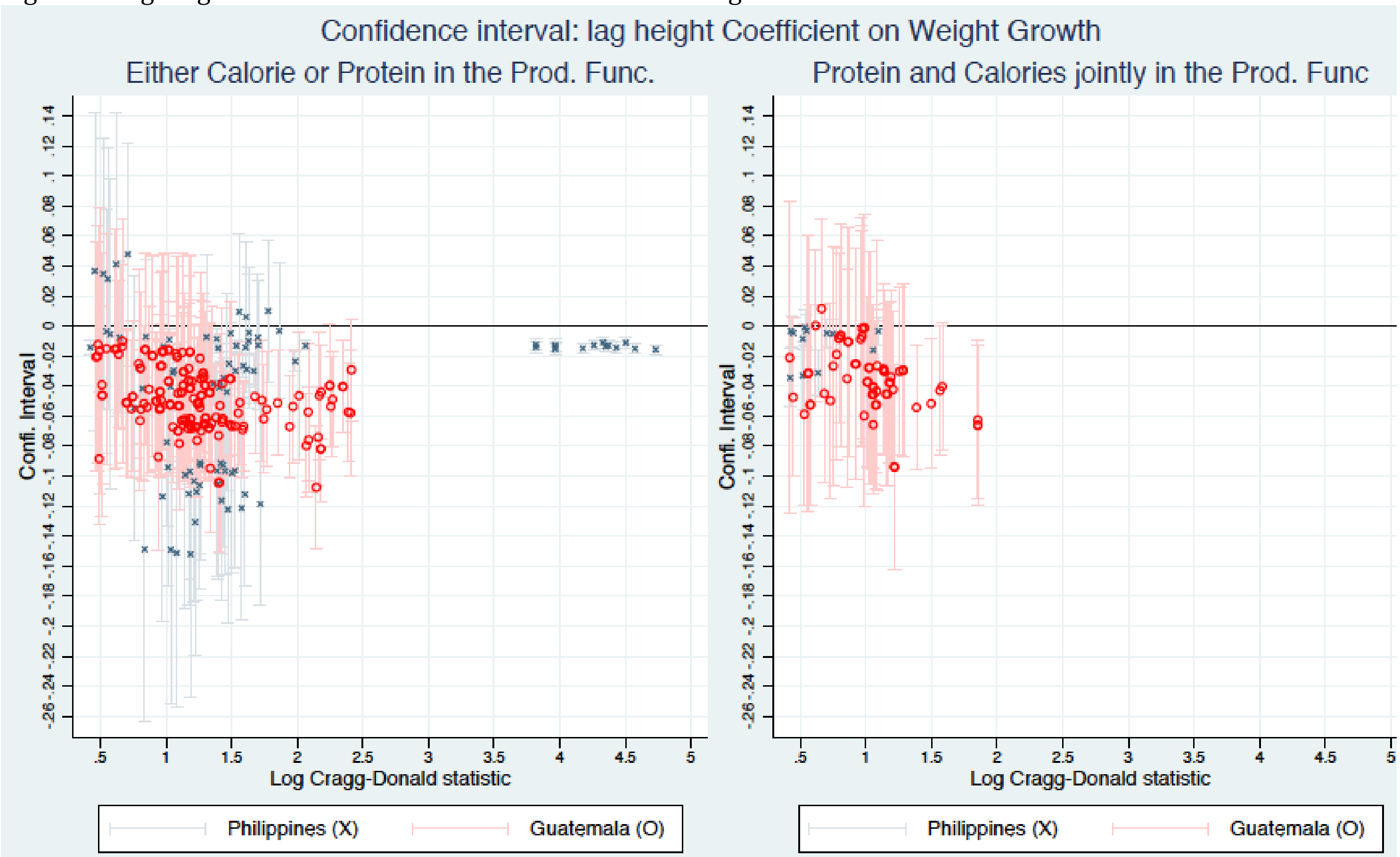
3: All regression include Lag 1 Height and lag 1 Weight as endogeneous variables

4: Instruments for Guatemala Include: combinations of 6 different lag annual prices, atole, atole*distance, Lag2 Height, Lag2 Weight

5: Instruments for Cebu Include: combinations of 3 different current and lag monthly prices, Lag2 Height, Lag2 Weight

6: Number of Instruments: 27% 4 instru., 38% 5 instru., 27% 6 instru. 6% 7 instru.

Figure 7: Lag height Coefficient and Confidence Interval – Weight Production Function



1: Includes only when Cragg-Donald > 1.5 and Hansen-J > .1

2: All regression include binary milk variable, continuous Diarrhea variable, gender, and gap in age across measurement as covariates

3: All regression include Lag 1 Height and lag 1 Weight as endogeneous variables

4: Instruments for Guatemala Include: combinations of 6 different lag annual prices, atole, atole*distance, Lag2 Height, Lag2 Weight

5: Instruments for Cebu Include: combinations of 3 different current and lag monthly prices, Lag2 Height, Lag2 Weight

6: Number of Instruments: 27% 4 instru., 38% 5 instru., 27% 6 instru. 6% 7 instru.

Figure 8: Lag weight Coefficient and Confidence Interval – Weight Production Function