APPENDICES:
Sound Body, Sound Mind?
Asymmetric and Symmetric Fetal Growth Restriction and Human Capital Development

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Appendix 1 The Identification & Classificaiton of IUGR

This section clarifies the definitions and data utilized to classify infants as being growth restricted. As stated in Section 4.1, there is a general problem that large, public use datasets generally do not have the necessary clinical measurements to construct such measures. Asymmetric and symmetric growth restriction are the subject of many papers in the medical literature. However, there is some academic debate concerning the definition and characteristics of asymmetric and symmetric growth restriction. The controversy includes debates about the proportion of asymmetric versus symmetric growth restriction, the causes of each subtype, which subtypes has worse health outcomes, and whether there are truly two distinct subtypes. Since Campbell and Thoms (1977) published their study on growth restriction, a proportion of 70 percent asymmetric and 30 percent symmetric has been widely cited as the prevalence of each subtype of IUGR. However, several studies find half of all IUGR infants are asymmetrically restricted and half are symmetrically restricted Martikainen (1992); Delpisheh et al. (2008), a 40 percent asymmetric and 60 percent symmetric division is seen in another study Salafia et al. (1995), and a 20 percent asymmetric and 80 percent sym-

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metric ratio is found in two studies Dashe et al. (2000); Nikkila, Kallen, and Marsal (2007). It should be noted that most of these studies use different methodologies and cutoffs for differentiating between the subtypes of IUGR.

Although typically asymmetric growth is thought to be accompanied by a better prognosis than symmetric growth restriction, Salafia et al. (1995), Dashe et al. (2000), and Nikkila, Kallen, and Marsal (2007) all find asymmetrically growth restricted infants to have more health problems and health anomalies than symmetrically growth restricted infants. Martikainen (1992) finds little or no evidence of differences between the two subtypes with regard to developmental delays. Finally, despite the fact that the vascular mechanism for "brain sparing" has been clinically observed in both animal and human subjects Uerpairojkit et al. (1996), there are potential challenges to the sparing hypothesis. Geva et al. (2006) find that infants that demonstrate growth impairment via ultrasound in the late second or early third trimesters, which is typical of asymmetric growth restriction, show signs of impaired memory function, and Roza et al. (2008) find that infants that exhibited the kind of vascular redirection in utero that is typical of asymmetric growth restriction showed signs of behavioral problems. Finally, Vik et al. (1997) finds no evidence of early or late onset of growth restriction using ultrasound diagnosis, and they find no evidence of larger head circumference among asymmetrically growth restricted infants.

Many of the studies employ the ponderal index (=birth weight/length^3) to distinguish between the asymmetric and symmetric subtypes Martikainen (1992); Delpisheh et al. (2008); Vik et al. (1997). However, this measure being shown to be a worse predictor of IUGR than birth weight alone Haggarty et al. (2004). Still others use a ratio of head circumference to abdominal circumference Dashe et al. (2000); Nikkila, Kallen, and Marsal (2007). However, it is unclear if this measure is appropriate since information about the absolute size of the head and abdomen is lost by using the ratio. Other common distinctions are head circumference or length below the 10th percentile or 2 standard deviations for symmetric IUGR.

The lack of a common methodology is likely the source of the divergent empirical results in the medical literature. Since definitive classifications are hard to come by, and there is no large-sample study that successfully demonstrates infants categorized by its method exhibit the expected characteristics from the literature, this paper adopts a "kitchen sink" approach. That is, I employ dozens of different classifications and show that the expected characteristics are exhibited by most of them, and I show that my results are consistent across most of the different classifications. I make no attempt to match a specific ratio of asymmetrically to symmetrically growth restricted infants due to a lack of agreement on such a ratio in the medical literature. However the different classifications employed have a good deal of variation in the ratio of asymmetric and symmetric, and this does little to affect the results. This paper's decompositions of restricted growth can be broken down into two main types: in-sample definition and out-sample definition. In-sample definitions are generated using percentile cutoffs created from the CPP data set. Out-sample definitions are generated using published standards of birth anthropometry in the medical literature.

1.A In-sample classification

Since the data set this paper employs is very large, it is reasonable to use in-sample measurements to create cutoff values between the general population and growth restricted infants and between asymmetrically and symmetrically growth restricted newborns. It is common in both the economics and the medical literature to define IUGR using only the neonate's birth weight. Typical cutoffs include low birth weight (LBW), which is medically defined as a birth weight less than 2500 grams, very low birth weight (VLBW), which is medically defined as a birth weight less than 1500 grams, and two standard deviations below the mean birth weight (due to the normality of birth weight this typically includes those below the 3rd percentile).

The most common medical definition for IUGR is birth weight below the 10th percentile for gestational age, which is the definition I employ in this paper. Infants are labeled as IUGR when their birth weight is below the 10th percentile of the sample controlling for race, for gender, and for one of four calculated gestational age categories.[1] However, since approximately half of the sample smoked during pregnancy—widely documented as a major cause of fetal growth restriction—it is likely that a much greater proportion than 10 percent of the sample experienced some form of growth restriction. Therefore an alternative definition of birth weight below the 20th percentile for gestational age is also tested.

Asymmetric growth restriction is characterized by the brain-sparing effect, which leaves brain growth—and thus head growth—largely intact. Thus I define asymmetric growth restriction as being IUGR yet having a head circumference at birth at or above the 10th percentile (controlling for race, gender, and gestational age). I also experiment with using the 5th percentile as the cutoff. Symmetrically growth restricted infants are the remaining IUGR infants, with both birth weight and head circumference below the 10th (5th) percentile.

[1] The categories are gestational age less than 32 weeks, from 32 weeks to 36 weeks, from 37 weeks to 40 weeks, and greater than 40 weeks. The main results of this paper are unchanged if values are instead calculated by actual gestation week. However, the values are slightly less precise due the small number of observations at some early gestational ages.

Since symmetric growth restriction also affects skeletal growth–and thus body length–I also create definitions incorporating crown-heel length at birth. Symmetric growth restriction is defined as having IUGR and having crown-heel length in lowest 10th (5th) percentile as well as head circumference below the 10th (5th) percentile.

The preferred in-sample definition of asymmetric growth restriction is having birth weight below the 10th percentile for gestational age, gender, and race and having a head circumference at or above the 10th percentile for gestational age, gender, and race. Symmetric growth restriction has the same birth weight standard and a head circumference below the 10th percentile cutoff. The 10th percentile cutoff for birth weight is preferred because it is by far the most commonly used standard, and the common alternative—birth weight more than two standard deviations below the mean—is far too restrictive, particularly when defining growth restriction from within the sample.

1.B Out-sample classification

Using within-sample growth standards to define IUGR and for decomposing IUGR into its subtypes could be problematic. The CPP data all come from urban areas. Thus, the black population and those of low socioeconomic status are over sampled. Furthermore, nearly half of the mothers in the CPP data smoked during pregnancy. Since smoking during pregnancy is linked to decreased birth weight, the CPP sample may be smaller than the general population. To remedy any potential problems arising from in-sample classification, I use well known growth standard publications from 1960s and 1970s to calculate a second set of IUGR variables.

The preferred period birth weight data come from a 50 percent sample of all US births from 1968, reported by Hoffman et al. (1974). These data are preferred due to the large sample size, nearly 1.23 million births, the large variation in gestational ages, and the ability to get percentile data broken down by both gender and race. The second set of data are from the famous Colorado birth studies Lubchenco et al. (1963); Lubchenco, Hansman, and Boyd (1966). These data contain percentiles on birth weight, head circumference, and length collected from approximated 5,000 births from 1948 to 1961. However, these data are limited to caucasian infants. The third reference is Usher and McLean (1969). These data are collected for 300 caucasian new borns from 1959 to 1963 in Montreal, Canada. Although these data are somewhat limited, they have three distinct advantages. First, the data come from some of the exact years the CPP is collected. Second it contains data on birth weight, head circumference, and length broken down by gestational age. And third, the data can be used for robustness checks because it contains anthropometric measures broken down across birth weight categories in addition to gestational age. The final data used come Miller and Hassanein (1971). These data include information on head circumference and length by percentile collected from 1,692 neonates born in the University of Kansas Medical Center. Even though the sample size for these data is large, it is not as large as the Colorado birth data. However, the measurements collected from the Colorado study have been shown to be significantly smaller than those taken in later studies. This is likely due to the high altitude of Denver, which, as previously mentioned, can significantly impact growth. The Kansas data is noted to contain larger infants, on average, than the Colorado data, and is therefore preferred to the more widely used Colorado data.

The preferred definitions from out-sample sources utilizes the birth weight data from Hoffman et al. (1974) and head circumference and crown-heel length standards from Miller and Hassanein (1971). These standards are chosen as preferred simply because they are formed using the largest samples (excluding the non-representative Colorado data).

For all of data from outside sources, symmetric IUGR is defined as having birth weight and head circumference (or birth weight, head circumference, and crown-heel length) below the 10th percentile for gestational age.[2] For all of the data except for the Montreal births, this can be done directly from the percentile information published in the respective papers. For the Montreal data, however, percentile breakdowns are not included, only mean and standard deviation by gestational age. Since birth weight is approximately normally distributed, the desired value is computed by subtracting the product of the standard deviation and the appropriate z-score from the mean to find the desired percentile for all three anthropometric measures.

Appendix 2 Alternative Definitions of IUGR

This appendix shows the results for the effects of asymmetric and symmetric growth restriction on IQ at ages 4 and 7 using alternative classifications for the growth restriction subtypes. The OLS results using the alternative in-sample classifications are found in Table A2, and the OLS results using the alternative classifications constructed from published birth standards are found in Table A3. The fixed effects results for in-sample and out-sample

[2]For these definitions the actual week of gestation is use since there are no sample size issue when using and outside data to define the cutoffs.

classifications are found in Tables 4 and 5, respectively.

The tables are organized such that each alternative definition is represented by a different column. Results using IQ at ages 4 are displayed above the corresponding age 7 results. A description of the each classification is displayed in Table A1. In-sample classifications use either the 10th or 20th percentile as a cutoff for identifying IUGR infants. The decomposition into subtypes is accomplished using head circumference alone or a combination of head circumference and crown-heel length. Cutoffs for these measures are either the 5th or 10th percentile. Symmetric is defined as having measurements below the cutoff, while asymmetric is defined as the complimentary set of IUGR infants. Unlike their in-sample counterparts, classifications that utilize published anthropometric birth standards (out-sample classifications) are all constructed using a 10th percentile cutoff (a standard in the medical literature). These classifications differ mainly on the data source from which the measurement standards are drawn (see Appendix Appendix 1 for further details). Other differences include how the measurement are standardized. For some sources the 10th percentile is only calculated for each gestational age; for others the cutoff is both gender and gestational age specific; and for the primary birth weight data sources, the 10th percentile cutoff is specific to race, gender, and gestational age.

These tables show overwhelming evidence that the results discussed in the paper are robust to changing the definition of the growth restriction subtypes. All classifications show results that are both quantitatively and statistically similar to the "preferred" classifications. Recall from Section 4 that preferred classifications are chosen based on comparability with the literature (in the case of in-sample classifications) or largest sample size (in the case of out-sample classifications), not based on results. Because of this, many of the alternative classifications show even stronger evidence of the brain-sparing effect.

Table 1: Summary of Alternative Definitions for IUGR

In-Sample Classifications

Label	**IUGR Definition**	**HC**	**C-H**	**Subtype Cutoff**
sym	BW <10%tile or ponderal index <10%tile		X	<10%tile
sym10_10*	BW <10%tile	X		<10%tile for race, gender, & gest. age
sym20_5	BW <20%tile	X		<5%tile for race, gender, & gest. age
sym10_5	BW <10%tile	X		<5%tile for race, gender, & gest. age
sym20_10	BW <20%tile	X		<10%tile for race, gender, & gest. age
sym20_10_10	BW <20%tile	X	X	<10%tile for race, gender, & gest. age
sym10_5_5	BW <10%tile	X	X	<5%tile for race, gender, & gest. age
sym10_10_10*	BW <10%tile	X	X	<10%tile for race, gender, & gest. age

Out-Sample Classifications

Label	**IUGR Definition**	**HC**	**C-H**	**Subtype Cutoff**
sym2	Hoffman et al (1974)	X		Lubchenco et al (1963) by gest. age
sym3	Hoffman et al (1974)	X		Usher & McLean (1969) by gest. age
sym4*	Hoffman et al (1974)	X		Miller & Hassanein (1971) by gender & gest. age
sym2ch	Hoffman et al (1974)	X	X	Lubchenco et al (1963) by gest. age
sym3ch	Hoffman et al (1974)	X	X	Usher & McLean (1969) by gest. age
sym4ch*	Hoffman et al (1974)	X	X	Miller & Hassanein (1971) by gender & gest. age
m_sym10	US Vital Statistics 2006-2008	X		CDC growth curves

* Indicates preferred definition, HC indicates "head circumference", C-H indicates "Crown-heel length". All Out-sample classifications use the 10 percentile cutoff. Fields indicate the source of anthropometric standard. All IUGR definitions account for differences in race, gender, and gestational age except for "sym" (no conditioning) and "m_sym10" (gender and gest. age only).

Table 2: OLS Results for IQ at Ages 4 and 7 Using Multiple In-Sample Def.

	sym	sym10_10	sym20_5	sym10_5	sym20_10	sym20_10_10	sym10_5_5	sym10_10_10
At Age 4								
Asymmetric	-2.175***	-1.348***	-1.809***	-2.012***	-1.636***	-1.687***	-1.720***	-1.206**
	(0.48)	(0.43)	(0.22)	(0.35)	(0.26)	(0.31)	(0.40)	(0.60)
Symmetric	-4.341***	-4.382***	-4.218***	-4.944***	-3.495***	-4.358***	-6.124***	-4.780***
	(0.37)	(0.33)	(0.33)	(0.40)	(0.26)	(0.34)	(0.53)	(0.39)
N	36656	34641	34641	34641	34641	34503	34503	34503
R^2	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
P-value for Equal β	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
At Age 7								
Asymmetric	-1.752***	-1.147***	-1.416***	-1.600***	-1.108***	-1.009***	-1.240***	-0.967*
	(0.41)	(0.39)	(0.19)	(0.30)	(0.22)	(0.26)	(0.36)	(0.56)
Symmetric	-3.013***	-3.699***	-3.767***	-4.264***	-3.190***	-3.730***	-5.332***	-4.109***
	(0.31)	(0.27)	(0.28)	(0.33)	(0.22)	(0.28)	(0.44)	(0.32)
N	38394	37003	37003	37003	37003	36857	36857	36857
R^2	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34
P-value for Equal β	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Controls for mother's age (as a quadratic function), the mother's height, indicators for marital status, indicators for the mother's and the father's education attainment, indicators for family income, the number of prenatal visits (as a quadratic function), and indicators for gestational age, race, gender, year of birth, and location of birth.

Table 3: OLS Results for IQ at Ages 4 and 7 Using Multiple Out-Sample Def.

	fgrsym2	fgrsym3	fgrsym4	sym2ch	sym3ch	sym4ch	m_sym10
At Age 4							
Asymmetric	-1.862***	-1.499**	-1.014	-2.024***	1.175***	-1.137**	-0.240
	(0.35)	(0.72)	(0.73)	(0.33)	(0.44)	(0.54)	(0.45)
Symmetric	-7.015***	-4.582***	-4.927***	-5.793***	-4.463***	-4.307***	-2.816***
	(0.77)	(0.35)	(0.38)	(0.47)	(0.40)	(0.32)	(0.23)
N	31910	34503	30967	32043	32043	31093	36799
R^2	0.31	0.31	0.31	0.31	0.31	0.31	0.31
P-value for Equal β	0.000	0.000	0.000	0.000	0.000	0.000	0.000
At Age 7							
Asymmetric	-1.710***	-1.230**	-0.724	-1.966***	0.616*	-1.116**	-0.010
	(0.30)	(0.62)	(0.64)	(0.28)	(0.36)	(0.48)	(0.40)
Symmetric	-5.502***	-3.655***	-4.021***	-4.541***	-3.575***	-3.603***	-2.625***
	(0.66)	(0.29)	(0.31)	(0.40)	(0.33)	(0.26)	(0.19)
N	34092	36857	32979	34232	34232	33108	38542
R^2	0.34	0.34	0.34	0.34	0.34	0.34	0.33
P-value for Equal β	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Controls for mother's age (as a quadratic function), the mother's height, indicators for marital status, indicators for the mother's and the father's education attainment, indicators for family income, the number of prenatal visits (as a quadratic function), and indicators for gestational age, race, gender, year of birth, and location of birth.

Table 4: Fixed Effects Results for IQ at Ages 4 and 7 Using Multiple In-Sample Def.

	sym	sym10_10	sym20_5	sym10_5	sym20_10	sym20_10_10	sym10_5_5	sym10_10_10
At Age 4								
Asymmetric	-4.543***	-0.801	-0.473	-1.694*	0.064	0.815	-1.987*	-0.372
	(1.48)	(1.30)	(0.68)	(1.02)	(0.76)	(0.85)	(1.07)	(1.59)
Symmetric	-3.052***	-3.693***	-4.453***	-4.029***	-3.549***	-2.958***	-3.579**	-3.310***
	(1.12)	(0.89)	(0.94)	(1.02)	(0.79)	(0.97)	(1.41)	(1.06)
N	6889	6915	6915	6915	6915	6889	6889	6889
Within R^2	0.04	0.04	0.05	0.04	0.05	0.04	0.04	0.04
P-value for Equal β	0.177	0.024	0.000	0.037	0.000	0.001	0.172	0.055
At Age 7								
Asymmetric	-3.207***	-0.545	-0.933	-1.938**	-0.663	-0.543	-1.746*	-1.143
	(1.17)	(1.15)	(0.59)	(0.92)	(0.65)	(0.73)	(1.05)	(1.71)
Symmetric	-2.231**	-3.748***	-3.426***	-3.617***	-2.784***	-2.854***	-3.027**	-3.564***
	(0.90)	(0.83)	(0.85)	(0.97)	(0.71)	(0.83)	(1.20)	(0.90)
N	6889	6915	6915	6915	6915	6889	6889	6889
Within R^2	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03
P-value for Equal β	0.222	0.007	0.003	0.082	0.006	0.014	0.203	0.099

Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Controls for mother's age (as a quadratic function), the mother's height, indicators for marital status, indicators for the mother's and the father's education attainment, indicators for family income, the number of prenatal visits (as a quadratic function), and indicators for gestational age, race, gender, year of birth, and location of birth.

Table 5: Fixed Effects Results for IQ at Ages 4 and 7 Using Multiple Out-Sample Def.

	fgrsym2	fgrsym3	fgrsym4	sym2ch	sym3ch	sym4ch	m_sym10
At Age 4							
Asymmetric	-0.929	-0.189	-0.048	-1.250	2.380**	0.832	0.896
	(1.07)	(2.04)	(1.89)	(0.99)	(1.21)	(1.56)	(1.36)
Symmetric	-7.296***	-4.257***	-3.694***	-5.522***	-5.263***	-3.505***	-3.501***
	(2.09)	(0.92)	(1.02)	(1.24)	(1.03)	(0.90)	(0.69)
N	6410	6889	6210	6436	6436	6232	6915
Within R^2	0.04	0.04	0.05	0.05	0.05	0.05	0.05
P-value for Equal β	0.002	0.032	0.042	0.002	0.000	0.004	0.001
At Age 7							
Asymmetric	-1.667*	-2.652	-0.780	-1.777**	0.052	-1.299	0.469
	(0.90)	(1.70)	(1.51)	(0.85)	(1.05)	(1.27)	(1.09)
Symmetric	-4.034**	-2.276***	-3.531***	-3.290***	-2.580***	-2.870***	-2.455***
	(1.67)	(0.82)	(0.92)	(1.13)	(0.95)	(0.85)	(0.63)
N	6410	6889	6210	6436	6436	6232	6915
Within R^2	0.03	0.02	0.03	0.03	0.03	0.03	0.03
P-value for Equal β	0.098	0.419	0.059	0.125	0.072	0.138	0.005

Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Controls for mother's age (as a quadratic function), the mother's height, indicators for marital status, indicators for the mother's and the father's education attainment, indicators for family income, the number of prenatal visits (as a quadratic function), and indicators for gestational age, race, gender, year of birth, and location of birth.

Appendix 3 Medical Literature

The medical literature generally agrees that infants affected by IUGR are at greater risk for health and developmental problems into early childhood. Newborns that experienced growth restriction in utero are at increased risk of perinatal suffocation, are 20 times more likely to have congenital malformations, are nine times more likely to develop infections, and are more likely to have hypoglycemia, low serum calcium levels in the blood, difficulty regulating body temperature, and respiratory distress. As children and adults, individual who experienced growth restriction in utero are at risk for permanently stunted growth, particularly if they were born preterm. There is also increased risk of developmental, behavioral, and cognitive problems Levene, Tudehope, and Thearle (2000); Martin, Fanaroff, and Walsh (2005). The fetal origins hypothesis, or Barker hypothesis, famously linked asymmetric growth restriction to coronary heart disease in adulthood. Further studies have shown associations between poor fetal growth and adult hypertension and diabetes, although the academic debate continues over the reliability of these studies Cunningham et al. (2009). Most medical literature centers on the collection of clinical data of infants with similar socioeconomic and demographic characteristics. The sample sizes are usually quite small, but closer to a controlled experiment.

Of particular interest is the current research on the cognitive effects of IUGR. Weisglas-Kuperus et al. (2009) examine the relationship between growth restriction and cognitive function, as measured by IQ scores at age 19. This study is unique in that it recognizes potential difference for asymmetric and symmetric growth restriction, as well as neonatal growth restraint. They define IUGR as birth weight or length below less than 2 standard deviations below the mean, adjusted for gestational age and gender. A growth restricted infant is considered of the asymmetric type if its head circumference is not 2 standard deviations below the mean. Neonatal growth restraint is defined as being normal size at birth, but having weight or length less than 2 standard deviations below the mean at 3 months of age. Controlling for maternal age, parental education, gender, and race they find that symmetric growth restriction has the largest effect on IQ (nearly a 6 point decrease), followed by neonatal growth restraint (4.1 point decrease), and asymmetric growth restriction still reduces IQ by 3.7 points compared to the non-growth restricted group. From the confidence intervals provided, these values do not appear to be statistically different, however. They also find evidence that being preterm affects IQ. However, this study has a small sample size (n=556) and few control variables.

Another study that tests the effect of birth outcomes on IQ is Breslau et al. (1994). Controlling for maternal education, maternal IQ, and race, they find a decrease in IQ at age six of nearly 5 points for low birth weight infants relative to those of normal birth weight. Although the authors do not explore differences in symmetric and asymmetric growth restriction, they do observe a gradient relationship between birth weight and IQ—those with the lowest birth weight had lower IQs. A follow up study examining math and reading achievement scores at age 11 found this cognition shock to be persistent. The difference in test scores at age 11 is mostly explained by IQ score at age 6, which suggests the cognitive deficit is a lasting effect from early childhood, but not a compounded effect Breslau, Johnson, and Lucia (2001). This provides evidence that negative effects to cognitive ability in early life may explain differences in outcomes in later life.

Ekeus et al. (2010) examine the impact of gestational age rather than birth weight. They use a large sample of Swedish birth records matched with cognitive test scores from military service. They find that gestational age predicts lower test scores in a gradient fashion—the largest effects are on those infants born very preterm (24-32 weeks gestation). According to another study, this effect may be due to decrease grey matter and white matter in the brain of the pre-term infant. Soria-Pastor et al. (2009) perform MRI scans on pre-term children that were born between 30 to 34 weeks of gestational age and compared them to a matched control sample. They find decreased volumes of grey and white mater in the preterm infants brains. They also show that grey matter reductions in certain regions of the brain are highly correlated with decreased IQ scores. Northam et al. (2011) confirm these results, finding that preterm infants have both lower white matter volume and IQ scores. These results are consistent with the hypothesis of symmetric growth restriction reducing the total cell number due to early onset growth injury.

My paper improves on this literature in several ways. First, I show the first empirical evidence of the “brain sparing” effect. That is, I show that there is statistically significant difference between the effect of symmetric growth restriction and the effect of asymmetric growth restriction on cognitive ability. Second, I test the robustness of these results to different definitions of asymmetric and symmetric growth restriction, and I show the results are also robust to using mother fixed-effects. Furthermore, my paper shows that the most important metric for determining cognitive ability is not birth weight or gestational age. Rather, head circumference alone is a better anthropometric measure for predicting IQ.

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