Price shocks and human capital: Timing matters*

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Abstract

The effect of economic shocks on human capital is theoretically ambiguous due to opposing income and substitution effects. Using child level information on schooling, child labour, and cognitive development, we investigate the effect of cocoa price fluctuations on human capital production in Ghana. We demonstrate that the timing of the price shock matters. For school-aged children, the substitution effect dominates: a price boom decreases schooling and increases child labour. An increase of one standard deviation in the current-year real producer price of cocoa significantly decreases current school attendance by 8.6 percentage points and the likelihood of being in the correct grade in the following year by 5.5 percentage points. For pre-school-aged children, however, the income effect dominates: early life and in utero booms in the real producer price of cocoa significantly increase Raven/IQ scores and grade attainment.

Keywords: Ghana; Cocoa Price Shocks, Child Labour; Schooling; Cognitive Development; Human Capital.

JEL Classification: I25; J1; O12

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1 Introduction

The dramatic fall of cocoa prices by almost a quarter between February and June 2020 has raised serious concerns regarding the ability of farmers in cocoa-producing countries to pay school fees with potentially long-lasting consequences for their children (Financial Times 2020). Although these concerns are legitimate, the effect of commodity price fluctuations on human capital investment is theoretically ambiguous due to opposing income and substitution effects. The income effect results from price shocks affecting the resources available for budget-constrained households to invest on their children. The substitution effect arises from the changing opportunity cost of staying in school (for children) and caring for children (for parents). The effect of commodity price shocks on human capital investment can be procyclical or countercyclical depending on whether the income effect dominates the substitution effect or vice versa. In this study, we show that fluctuations in the real producer price of cocoa have different effects on human capital development in Ghana depending on the age of the affected children. In particular, for school-aged children the substitution effect dominates the income effect. When there is a cocoa price boom, school aged children leave school (or their entry is delayed) to participate in child labour activities. In contrast, for young (in utero or early-age) children the income effect dominates the substitution effect. In this case, a cocoa price boom improves human capital production.

We contribute to an active literature assessing the effect of economic shocks on human capital production (Jensen, 2000; Beegle et al., 2006; Duryea et al., 2007; Kruger, 2007; Cogneau and Jedwab, 2012; Atkin, 2016; Shah and Steinberg, 2017; Carrillo, 2020). Some of these studies find that the income effect dominates: schooling increases while child labour declines (Jensen, 2000; Beegle et al., 2006). Others document that the substitution effect is particularly important: human capital investment in schooling drops as child labour increases (Duryea et al., 2007; Kruger, 2007; Shah and Steinberg, 2017; Atkin, 2016; Carrillo, 2020). The age of children at the time of the shock and the specific country context (such as the availability of free education) may explain such mixed results in the literature. As far as we know, with the exception of a study in India by Shah and Steinberg (2017), our study is unique in shedding light on the importance of the timing of price shocks along a child's life in explaining differences in schooling, child labour and cognitive development.

Our study also contributes to the debate on how export booms and policies related to export promotion may affect human capital accumulation in developing countries. Other relevant studies include Kruger (2007), Atkin (2016), and Carrillo (2020). However, these studies either focus on the contemporaneous effect of the boom on schooling and child labour or on the long-term human capital accumulation effects of booms that occur during the period of schooling. Our study encompasses the lifecycle by considering the effect of cocoa price fluctuations on cognitive development in early life, as well as, schooling and child labour during school age, and, to some extent, long-term human capital accumulation by adults in Ghana.

In Ghana, some regions are suitable for cocoa production while others are not. Thus, from a methodological point of view, we estimate the average effect of price shocks on schooling, child labour, cognitive outcomes and other outcomes in cocoa-producing regions, considering other regions as a comparison group. The causal interpretation of our results depends on the absence of omitted factors or macroeconomic trends potentially correlated with both the price shocks and the outcomes. To reduce this risk, we introduce region, year of birth and survey year fixed effects, as well as region-specific time trends. We also assess the sensitivity of our results to other identification threats, including the exogenous nature of the price shocks, confounding weather shocks, and mortality and fertility selection.

Our methodological approach is similar to Cogneau and Jedwab (2012), Edmonds and Pavcnik (2005), and Beck et al. (2019). Cogneau and Jedwab (2012) focus on the differentiated effect of a fall in price, comparing children between 7 and 15 years of age from cocoa-producing and non-cocoa-producing regions in Ivory Coast. Similar to the present study, Beck et al. (2019) directly use price information to assess the effect of coffee-price variation in Vietnam. They find a decreasing effect of coffee prices on child labour, and in particular among children 15 to 19 years of age, but do not find any effect on educational outcomes. Edmonds and Pavcnik (2005) also document a decreased reliance on child labour when the price of rice increases in Vietnam. However, beyond the contextual differences, any comparison to these papers is limited since they focus on school-aged children. We shed light on the importance of the timing of shocks by analysing the effect of price shocks occurring at an early age as well. For school-aged children, both income and substitution effects are important, yet in the context of free education the substitution effect may dominate the income effect. Thus, during a temporary economic boom, parents may decide not to send their children to school in order to put them to work and then send them back to school after the economic boom is over (Kruger, 2007). For young (pre-school-aged) children, the income effect may be particularly relevant. We follow Shah and Steinberg (2017) in hypothesizing that the age of children plays an important role in the relationship between commodity price shocks and human capital.

We investigate the effect of cocoa price variation on human capital development at different ages in Ghana, one of the largest cocoa exporters. Exploiting price variation between cocoa-producing and non-producing regions, we first assess the impact on schooling (and child labour) for school-aged children. Based on six Ghana Living Standard Surveys (GLSS), we find that children surveyed in producing regions during a cocoa price boom are less likely to attend school. An increase of one standard deviation in the current-year real producer price of cocoa significantly decreases school attendance by 8.6 percentage points. This is equivalent to a 10.8% decline in the average attendance rate. In addition, a cocoa price boom in the previous year significantly decreases the likelihood of a child being in the right grade for her age in the following year. An increase of one standard deviation in the previous year's real producer price of cocoa significantly decreases the likelihood of being in the correct grade in the following year by 5.5 percentage points. This represents a 25% fall in the average grade-for-age rate.

Next, we estimate the effect of cocoa price shocks at an early age on human capital development. In absence of contemporaneous measures of human capital for pre-school-aged children, we assess the impact of early-life shocks on the acquisition of cognitive skills. Cognitive abilities are indeed known to embed the dynamic process of skill formation and determine long-term schooling and labour market outcomes (Currie and Thomas, 2001; Heckman, 2007). We exploit information on cognitive abilities measured by the Raven/IQ test score for children 9 to 17 years of age and grade attainment for children 6 to 17 years of age. Combining data from the Ghana Living Standards Surveys and the Ghana Education Impact Evaluation Survey (GEIES), we find that a cocoa price boom at an early age significantly increases Raven/IQ scores and grade attainment. A one standard deviation increase in the real producer price of cocoa translates to an increase of 2.8 percentage points in the number of correct Raven/IQ items answered by children, which is equivalent to 6% of the average score. An increase of one standard deviation in the real producer price of cocoa boosts grade attainment by 0.46 years, which is 16% of the average grade attained by children in the sample. We further show that such effects are driven by cocoa price shocks occurring in utero. This is consistent with the so-called 'foetal origins' hypothesis, which predicts that the period in utero is the most critical in terms of health and human capital development. While the literature has mainly focused on the effect of early-life exposure to shocks on adult health or human capital outcomes, we complement existing studies seeking to test the so-called foetal origins hypothesis (Barker, 1992; Almond and Currie, 2011) in younger individuals (Figlio et al., 2014; Almond et al., 2015; Shah and Steinberg, 2017).

The remainder of the paper is organized as follows. The next section presents the relevant background information on Ghana. Section 3 is the analysis section where the identification strategy, the data, and the results are presented. Section 4 offers some concluding remarks.

2 Background

The Cocoa Coast. After its independence, Ghana, formerly known as the Gold Coast, became one of the major exporters of cocoa. Though it fluctuates across time, the cocoa sector constitutes a major economic sector in the country. Its share of GDP reached more than 5 percent in the 1970s. Between 2001 and 2005, the sector contributed to about 10 percent of agricultural GDP (Kolavalli and Vigneri, 2018). The cocoa sector is a major source of livelihood for about 800,000 farmers and a substantial number of other people involved in trade, transportation and processing. Moreover, it is one of the major sources of export revenue. For example, in 2009/10 Ghana exported more than half a million (566,700) MT of cocoa beans, accounting for about 21% of total exports (The World Bank, 2013).

Schooling. Following a 1987 reform, education in Ghana was structured as 6 years of primary school (age 6 to 11); 3 years of junior high school (age 12 to 14) and 3 years of senior high school (age 15 to 17) (see Figure A.1 in online Appendix A). Based on the Ghana Living Standard Surveys, school enrolment in Ghana has shown remarkable progress in the last three decades. In 1987/88, about 61% of children aged between 6 and 17 were enrolled in school, and that number rose to 87% in 2012/13. The variation in attendance by age shows that fewer students attend school as age increases. In 1987/88, 63% of children aged between 6 and 11, 64% of children aged between 12 and 14, and only 50% of children aged between 15 and 17 attended school. However, in 2012/13, these percentages rose to 90%, 90% and 76%, respectively. Gender disparities in school attendance have also narrowed. In 1987/88, 67% of boys and only 55% of girls went to school. In 2012/13, these percentages converged. The attendance rate for both school-aged boys and girls was similar at 87%.

Child labour. Child labour is one of the main reasons why children in many developing countries are dropping out of school. In Ghana, about 29% of school-aged children are involved in work activities. Around 30% of boys and around 27% of girls participate in a work activity, mostly for their families. However, girls are likely to be more involved in household chores (83% of girls compared to 75% of boys).

3 Analysis

3.1 Empirical strategy

The main objective of this study is to explore the differential effect of cocoa price fluctuations on school-aged children and younger children. To that end, we formulate the following intent-to-treat specification as our empirical strategy:

$$H_{iryt} = \alpha_r + \mu_y + \theta_t + \delta_{rt(y)} + \beta \text{CocoaPrice}_{t(y-1)} \times \text{CocoaProducer}_r + X'_{iryt}\Upsilon + \varepsilon_{iryt} \quad (1)$$

Contemporaneous shocks and schooling. To understand the impacts of cocoa price fluctuations on school-aged children, we investigate the effects of contemporaneous price shocks on school attendance and grade-for-age outcomes. We estimate equation (1) using a linear probability model (LPM) and resort to sampling weights to obtain nationally representative estimates. In this contemporaneous analysis, H_{iryt} is the schooling outcomes (attendance and grade-for-age) of child i born in region r at year y and surveyed in year t. CocoaPrice_t is the logarithm of the real producer price of cocoa in year t and CocoaProducer_r indicates whether cocoa is produced in region r. As described in more detail in online Appendix B.2, the real cocoa price comes from the farm-gate price provided by Teal (2002). The indicator for cocoa-producing regions is based on the percentage of farmland occupied by cocoa as a fraction of the total farmland area computed using the EGC-ISSEA Ghana Panel Survey (see online Appendix B.2).[1] The interaction of CocoaPrice_t and CocoaProducer_r gives

[1]These data were collected by the Economic Growth Center (EGC) at Yale University and the Institute of Statistical, Social, and Economic Research (ISSER) at the University of Ghana, Legon.

us the current-year price shock. In cocoa-producing regions, yearly variation in farm-gate cocoa prices results in transitory changes in labour market conditions and income, with no apparent effect in regions that do not produce cocoa. Following similar studies (Adhvaryu et al., 2019; Carrillo, 2020), we loosely label these price-induced differential economic changes in cocoa-producing and non-producing regions as price shocks. X_{iryt} is a vector of household and child characteristics (age of the child (in dummies), gender of the child and gender of the head of household). We also control for α_r, region-of-birth fixed effects; μ_y, year-of-birth fixed effects; θ_t, interview-year fixed effects; and δ_{rt}, region-specific time trends. The parameter of interest β estimates the average effect of the current-year price on schooling in regions that produce cocoa. The identification of the causal effect of price shocks on schooling outcomes depends on the assumption that, conditional on year-of-birth, survey-year, and region fixed effects and region-specific time trends, contemporaneous price shocks are not related to omitted factors that affect schooling outcomes.

Early life shocks, cognitive development and grade attainment. In the absence of outcomes measured at pre-school ages, we estimate the impact of early-life price fluctuations on later childhood cognitive development outcomes. We estimate equation (1) using ordinary least square (OLS) and applying sampling weights. In this analysis H_{iryt} designates cognition outcome variables – namely Raven/IQ test score or grade attainment – for individual i born in region r at year y and surveyed at time t. The cocoa price is defined as CocoaPrice_{y-1} and is the logarithm of the real producer price of coca in the year before the year of birth (in utero).[2] The interaction of CocoaPrice_{y-1} and CocoaProducer_r captures shocks occurring in utero or early in life. δ_{ry} denotes region-of-birth-specific year of birth trends.[3] In this

[2]Due to lack of precision in the date of birth information, in utero is defined as the year before the year of birth. This strategy is widely used in the literature (Adhvaryu et al., 2015; Shah and Steinberg, 2017). Moreover, when we consider average early-life shocks, CocoaPrice_{y-1} represents the average real producer price of cocoa (in log) during the period in utero and up to age 2.

[3]Note that we avoid the concern related to migration selection, usually encountered in the literature (Akresh et al., 2012; Shah and Steinberg, 2017). Unobserved migration by households (children) has been found to potentially bias results regarding early-life shocks

analysis, the parameter of interest β captures the effect of exposure to in-utero or early-life (income) shocks. Specifically, it measures the average effect of in-utero (early-life) cocoa prices on cognitive development outcomes in regions that produce cocoa. The identification of the causal effect of early-life price shocks on cognitive outcomes and grade attainment rests on the assumption that, conditional on birth-year and region-of-birth fixed effects, and region-specific time trends, early-life or in utero price shocks are not correlated with omitted factors that also impact the cognitive development outcomes.

Instrumental variable strategy. Despite the fact Ghana represents about 21% of global cocoa exports, Ghana is a price taker (Bulir, 1998). A long-known characteristic of the cocoa market is the limited short-run cocoa supply response to economic incentives (Behrman, 1968). Most farmers have little ability to respond to price variation in terms of production capacities. Cocoa production is mostly a function of weather conditions and political stability. Demand is also mostly inelastic (Behrman, 1968). Nonetheless, there is a concern that our farm-gate price may be related to the political economy of Ghana (the tax or subsidy policies, for instance) which may also influence investment in education in the country. To deal with this concern, we experiment with alternative specifications: We use international (world) price as an instrument for Ghana producer price in an IV strategy. Specifically, we instrument the main variable of interest ($\text{CocoaPrice}_t \times \text{CocoaProducer}_r$) by the interaction between the international cocoa price and the variable indicating whether cocoa is produced in the concerned region ($\text{WorldCocoaPrice}_t \times \text{CocoaProducer}_r$). In the early-life analysis, the subscript t is replaced by the subscript $y-1$. International prices are retrieved from World Bank Commodity Markets.[4]

Inference. Standard errors are clustered at the region level to deal with correlation within region of birth. Given the low number of clusters (10 regions), the precision of the estimates may be affected. We report p-values calculated using wild bootstrapping methods

since early-life exposure to shocks could be incorrectly assigned based on a child's current region of residence. In our case, the data used reports the region of birth for children. Migration selection is therefore not a major issue.

[4]See https://www.worldbank.org/en/research/commodity-markets.

(Cameron et al., 2008; Cameron and Miller, 2015), and inference is based on these p-values.

3.2 Data

Schooling data. To analyse the contemporaneous effect of price shocks on schooling, we use the Ghana Living Standard Surveys (GLSS1, GLSS2, GLSS3, GLSS4, GLSS5, and GLSS6).[5] These surveys use nationally representative samples to collect individual, household, community and price information. Because the analysis is conducted at the child level, we restrict the sample to about 59,000 individuals aged 6 to 17 years old.

The main schooling outcome variables, H_{iryt} in Equation (1), are attendance and grade-for-age. The GLSS surveys ask whether household members are currently attending school. Attendance takes the value of 1 if the member of the household is currently attending school and 0 otherwise. Another schooling variable is grade-for-age. We define grade-for-age as a binary variable that takes the value of 1 if a child is in the correct grade for his or her age. Table B.1 in online Appendix B.1 reports summary statistics for these outcome variables and controls used in this analysis. 79% of children in the pooled sample (all children) are currently attending school. On average children in the sample attained 3 years of schooling and only 22% of children are in the right grade for their age.

Data on cognition. To gauge the effect of price shocks at an early age, we investigate the effect of these shocks on the cognitive development of children. Following Glewwe et al. (2001), Field et al. (2009) and Ampaabeng and Tan (2013), we focus on the Raven/IQ test and grade attainment as measures of cognition. To understand the impact of early life-shocks on intelligence or IQ, we use Raven test scores (Raven's Progressive Matrices).[6] The data on this test come from two sources: the Ghana Living Standards Survey Round 2 (GLSS2) and the Ghana Education Impact Evaluation Survey (GEIES) conducted in 2003. GLSS2 is considered to be the precursor of the GEIES. GLSS2 includes an education module, that

[5]Child labor supply data used in supporting analyses are described in online Appendix B.2.

[6]Figure A.2 in online Appendix A shows an example of the Raven/IQ test.

tested the cognitive development and skill achievement of household members and teachers in 85 sampling clusters randomly selected from the entire GLSS2 sample of 170 clusters. In 2003, the GEIES was conducted in 84 of the 85 clusters where educational achievement scores had been collected for the GLSS2.[7] The 2003 survey collected data from 1,740 households and 8,000 individuals. In both surveys, household members aged 9 to 55 years took the tests. In this study, we pool both surveys and restrict the sample to children aged 9 to 17, as we focus on child cognitive development.[8] For grade attainment outcomes, we exploit the Ghana Living Standard Surveys (GLSS1, GLSS2, GLSS3, GLSS4, GLSS5 and GLSS6). Summary statistics for the Raven/IQ and grade attainment are presented in Table B.2 in online Appendix B.1. On average, children in our sample answered 49% of Raven/IQ questions correctly and attained 3 years of schooling.

3.3 Results

Contemporaneous price effects on schooling. Table 1 reports the main results regarding the contemporaneous effects of price shocks on children's attendance and educational progression. Panels A and B report the effect of current-year price shocks on the probability of current attendance. Panels C and D show the effect of previous-year price shocks on the probability of a child being in the right educational track.[9] Panels A and C show results without region-specific time trends, while Panels B and D refer to results with region-specific time trends. Column (1) provides estimates on the pooled sample (children aged 6 to 17), column (2) on the sample of primary school children (aged 6 to 11), column (3) on the sample of children of junior high school age (12 to 14) and column (4) on the sample of children of

[7] One of the clusters surveyed in 1988/89 (GLSS2) was no longer inhabited in 2003.

[8] The datasets also include information on other achievement scores. These outcomes are described in online Appendix B.2.

[9] If children experience a price boom in the previous year and decide to drop out of school, they fall behind in terms of current-year grade attainment. Thus, it is intuitive to use previous-year price shocks instead of current-year price shocks in the case of the grade-for-age analysis.

senior high school age (15 to 17). Columns (1) and (2) indicate that price shocks significantly decrease school attendance and grade-for-age.

For children born in regions that produce cocoa, when the real cocoa price increases, school attendance and grade-for-age fall. In panel B, column (1), we can see that a 1 log point increase in the current-year real producer price of cocoa significantly deteriorates the likelihood of current attendance by 22 percentage points. This implies that an increase of one standard deviation (0.39 log points) in the real producer price of cocoa reduces school attendance by 8.6 percentage points. This is equivalent to 10.8% of the average attendance rate. In Panel D, Column (1), a 1 log point increase in the previous year real producer price of cocoa significantly lowers the likelihood of being in the correct grade by 14 percentage points. This implies that an increase of one standard deviation in the real cocoa price reduces grade-for-age by about 5.5 percentage points. This is equivalent to 25% of the average grade-for-age rate.

In Table 2, we report the second-stage results from IV estimations that apply world prices as an instrument for Ghana producer prices.[10] The table shows that the IV results are largely similar to our main results. Unlike the baseline, however, the IV results show significant effects of cocoa prices on the attendance of children in junior high school and senior high school (columns 3 and 4). In conclusion, higher prices decrease attendance and grade-for-age.

Moreover, we find that the resulting decrease in school attendance and grade-for-age for school-aged children is associated with a surge in child labour. During a cocoa price boom, children engage in significantly more work. In regions that produce cocoa, an increase in the current-year real cocoa price increases any form of employment for all groups of children. We also find evidence that a higher current-year price leads to more work in the agricultural and non-agricultural sectors.[11]

[10] We report the first-stage result in Table C.1 in online Appendix C.1. The results show that world prices significantly and strongly predict the farm-gate prices (with a Kleibergen-Paap F-statistic ranging well above 10).

[11] Results are presented in Table C.4 and Table C.5 in online Appendix C.2. Online Ap-

Table 1: Estimated effect of current- and previous-year cocoa price shocks on schooling

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Current Attendance			
Panel A: without region-specific trends				
Cocoa Price × Cocoa Producer Region	-0.255***	-0.271***	-0.249***	-0.206**
	(0.070)	(0.073)	(0.069)	(0.073)
	[0.000]	[0.007]	[0.000]	[0.024]
Observations	58,568	31,533	14,829	12,206
Panel B: with region-specific trends				
Cocoa Price × Cocoa Producer Region	-0.221**	-0.299***	-0.142	-0.093
	(0.070)	(0.069)	(0.074)	(0.105)
	[0.043]	[0.034]	[0.137]	[0.499]
Observations	58,568	31,533	14,829	12,206
	Grade-for-age			
Panel C: without region-specific trends				
Cocoa Price × Cocoa Producer Region	-0.097***	-0.126***	-0.066*	-0.048
	(0.022)	(0.031)	(0.019)	(0.024)
	[0.027]	[0.032]	[0.057]	[0.127]
Observations	49,621	26,451	12,629	10,541
Panel D: with region-specific trends				
Cocoa Price × Cocoa Producer Region	-0.143***	-0.224***	-0.020	-0.053
	(0.031)	(0.045)	(0.029)	(0.058)
	[0.006]	[0.004]	[0.508]	[0.433]
Observations	49,621	26,451	12,629	10,541
Region of Birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Year of Birth FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age (entered in fixed effects), and gender of household head. Panel A and B report results on current attendance, and panel C and D show the effect of price shock on grade-for-age. Survey weights are used in the regression estimations.

In summary, in cocoa-producing regions higher cocoa prices decrease schooling and increase child labour. This implies that parents may temporarily pull their children out of school or delay their enrolment and put them to work to reap the benefits of an economic boom. Shah and Steinberg (2017) and Kruger (2007) also find that during economic booms in India and Brazil, children drop out of school to engage in child labour activities.

pendix C.2 also contains detail and additional analysis of child labour.

Table 2: Exploiting international price as Instrument(IV): Second-stage results

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Current Attendance			
	Panel A: without region-specific trends			
Cocoa Price × Cocoa Producer Region	-0.258***	-0.271***	-0.245***	-0.229***
	(0.069)	(0.071)	(0.060)	(0.081)
	[0.000]	[0.001]	[0.000]	[0.007]
Observations	58,568	31,533	14,829	12,206
	Panel B: with region-specific trends			
Cocoa Price × Cocoa Producer Region	-0.235**	-0.281**	-0.143*	-0.218**
	(0.077)	(0.083)	(0.054)	(0.128)
	[0.025]	[0.027]	[0.067]	[0.047]
Observations	58,568	31,533	14,829	12,206
	Grade-for-age			
	Panel C: without region-specific trends			
Cocoa Price × Cocoa Producer Region	-0.105**	-0.142**	-0.057	-0.055
	(0.020)	(0.029)	(0.016)	(0.022)
	[0.010]	[0.016]	[0.236]	[0.153]
Observations	49,621	26,451	12,629	10,541
	Panel D: with region-specific trends			
Cocoa Price × Cocoa Producer Region	-0.136***	-0.206***	-0.019	-0.069
	(0.028)	(0.037)	(0.045)	(0.040)
	[0.003]	[0.005]	[0.659]	[0.192]
Observations	49,621	26,451	12,629	10,541
Region of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age (entered in fixed effects), and gender of household head. Panel A reports results on current attendance, and panel B shows the effect of price shock on grade-for-age. Survey weights are used in the regression estimations.

Early life and in utero price effects. Table 3 presents the effects of early-life shocks and in utero price shocks on Raven/IQ test scores and grade attainment. Panel A presents results regarding early-life shocks, while panel B shows results for in utero price shocks. Columns (1) and (3) report results without region-specific trends, while columns (2) and (4) provide results with region-specific trends. The table shows that, in general, higher early-life or in utero prices lead to better childhood cognitive development outcomes.[12] For instance, panel

[12]In panel A, although the result without region-specific trends show an unexpected significant negative effect, our preferred specification (with region-specific trends) yields the

Table 3: Estimated effect of early-life and in utero cocoa price shocks on cognition

	Age 9 to 17		Age 6 to 17	
	(1) Raven/IQ	(2) Raven/IQ	(3) Grade	(4) Grade
	Panel A: Effects of average early life price shocks			
Early-life Cocoa Price × Cocoa Producer Region	11.464**	12.842*	-1.055***	1.394**
	(4.174)	(4.926)	(0.112)	(0.179)
	[0.044]	[0.055]	[0.000]	[0.017]
Observations	2,826	2,826	49,621	49,621
	Panel B: Effects of in utero price shocks			
In-utero Cocoa Price × Cocoa Producer Region	8.533*	11.259**	-0.401	1.097**
	(2.746)	(3.698)	(0.116)	(0.116)
	[0.056]	[0.041]	[0.227]	[0.012]
Observations	2,826	2,826	49,621	49,621
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region of birth trends	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age (entered in fixed effects) and gender of household head. The Raven/IQ includes children of ages 9 to 17, while grade is reported for children of age 6 to 17. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

A in column (2) indicates that a one standard deviation (0.217) increase in cocoa prices at an early age is associated with a 2.78 percentage point rise in Raven/IQ test scores for the sample of children aged 9 to 17. This corresponds to a 6% increase at the mean. Column (4) shows an average increase of 0.46 years in grade attainment following a one standard deviation (0.326) rise in cocoa prices. The magnitude is sizeable, translating into a 16% change at the mean. In panel B we can see that the in utero price shock has also significant positive effects on both outcomes. To gauge the economic impact of the shock, we estimate

expected positive relationship between higher early-life prices and grade attainment.

the impact of Raven/IQ test scores on other cognitive achievement test scores.[13] The gain in Raven/IQ score due to an early-life price boom translates into a gain of 2.1 percentage points in simple reading test scores, 1.6 percentage points in simple maths test scores, 0.92 percentage points in advanced reading and 0.51 percentage points in advanced maths test scores.

In Table 4, we report second-stage results from IV estimations.[14] Although not precisely estimated (especially for the Raven score outcome), the IV results paint a similar picture to the baseline results. In sum, children conceived during times of higher cocoa prices and born in cocoa-producing regions tend to have higher Raven/IQ scores and higher grade attainment.[15] Similarly, Shah and Steinberg (2017) also find in utero and early-life economic booms strongly and positively affect human capital development in India.

Robustness. Our main results are robust to using alternative instruments, controlling for confounding weather shocks, the role of selective mortality and fertility decisions, and to alternative variable definitions and specifications. All results are presented and discussed in online Appendix D. We also discuss gender imbalances in the human capital effects of price shocks in online Appendix D.5. Our results do not identify gender imbalances in the contemporaneous effects of price shocks on schooling. In turn, for the early-life analysis, boys are more vulnerable to early-life shocks.

[13] Table C.3 in online Appendix C.3 reports these results.

[14] We report the first-stage results in Table C.2 of online Appendix C.1.

[15] We document the mechanisms behind early-life price shocks affecting the cognitive development of children in online Appendix C.4. We find suggestive evidence that these effects may result from both improved prenatal nutrition and childhood investment. Moreover, in online Appendix C.5, we report evidence on price shocks experienced at early age and at school age persisting into adulthood.

Table 4: Exploiting international price as an IV, second stage

	Age 9 to 17		Age 6 to 17	
	(1) Raven/IQ	(2) Raven/IQ	(3) Grade	(4) Grade
	Panel A: Effects of average early life price shocks			
Early-life Cocoa Price × Cocoa Producer Region	10.846	6.477	1.189	6.938
	(5.723)	(4.407)	(0.503)	(1.330)
	[0.205]	[0.217]	[0.247]	[0.142]
Observations	2,826	2,826	49,621	49,621
	Panel B: Effects of in utero price shocks			
In-utero Cocoa Price × Cocoa Producer Region	1.605	1.510	2.058*	4.726
	(3.456)	(3.389)	(0.449)	(0.688)
	[0.674]	[0.698]	[0.085]	[0.125]
Observations	2,826	2,826	49,621	49,621
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region of birth trends	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age (entered in fixed effects) and gender of household head. The Raven/IQ includes children of ages 9 to 17, while grade is reported for children of age 6 to 17. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

4 Conclusions

In this study, we explore whether there is a differential effect of cocoa price fluctuations along a child's lifecycle. We find that a cocoa price boom positively affects the human capital production of young children, while it is negatively related to human capital investment on older children. In other words, the substitution effect is dominant for older (school-aged) children, while the income effect is dominant for young (including in utero) children.

Exploiting the Ghana Living Standard Surveys, we estimate the impact of real cocoa price fluctuations on schooling and grade-for-age outcomes. Controlling for region, year of birth and survey-year fixed effects, and region specific time trends, the coefficients estimate the differential effect of current-year prices on attendance and previous year prices on grade-for-age in regions that produce cocoa. We find that a cocoa price boom negatively affects attendance and grade-for-age. An increase of one standard deviation in the current-year real producer price of cocoa significantly decreases current attendance by 8.6%. This is equivalent to 10.8% of the average attendance rate. An increase of one standard deviation in the previous-year real producer price of cocoa significantly decreases the likelihood of being in the correct grade in the following year, by 5.5%. This is equivalent to 25% of the average grade-for-age rate. For school-aged children, the substitution effect is dominant.

Exploiting the Ghana Living Standards Surveys and the Ghana Education Impact Evaluation Survey (GEIES), we also explore the effect of price fluctuations on cognitive development and grade attainment. In utero cocoa price booms increase Raven/IQ scores and grade attainment. An increase of one standard deviation in the real producer price of cocoa in utero increases Raven/IQ scores by 2.8 percentage points and increases the grade attained by 0.46 years. For young (in utero) children, the income effect is important.

Our results are important not only for understanding the consequences of price shocks, a very common source of instability in developing countries, but also to shed light on the possible unintentional effects of policy-induced income shocks. In many developing countries, designing social safety net policies that integrate public work programmes is increasingly popular. Prominent examples include the National Rural Employment Guarantee Act that started in 2005 in India, the Productive Safety Net Program that has been implemented in Ethiopia since 2005, the Productive Safety Net Program in place since 2012 in Tanzania and the Productive Safety Net Program that started recently in Ghana. These involve a public work programme in which beneficiaries engage in public work activities for relatively good wages. The results from this study suggest that even though access to such kind of resources early in life increases cognitive development outcomes later in childhood, for older children it might have a detrimental effect on schooling. When outside options improve (i.e. wages increase), children may substitute work for school, and as a result, human capital production decreases. More research on this topic is certainly needed. Policy makers should take into account such negative potential consequences of social safety net programmes. In this regard, lump sum grants may minimize these unintended consequences (Shah and Steinberg, 2017).

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Separate Appendixes with Supplemental Material for:

Price shocks and human capital: Timing matters

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Abstract

This document contains a set of appendixes with supplemental material.

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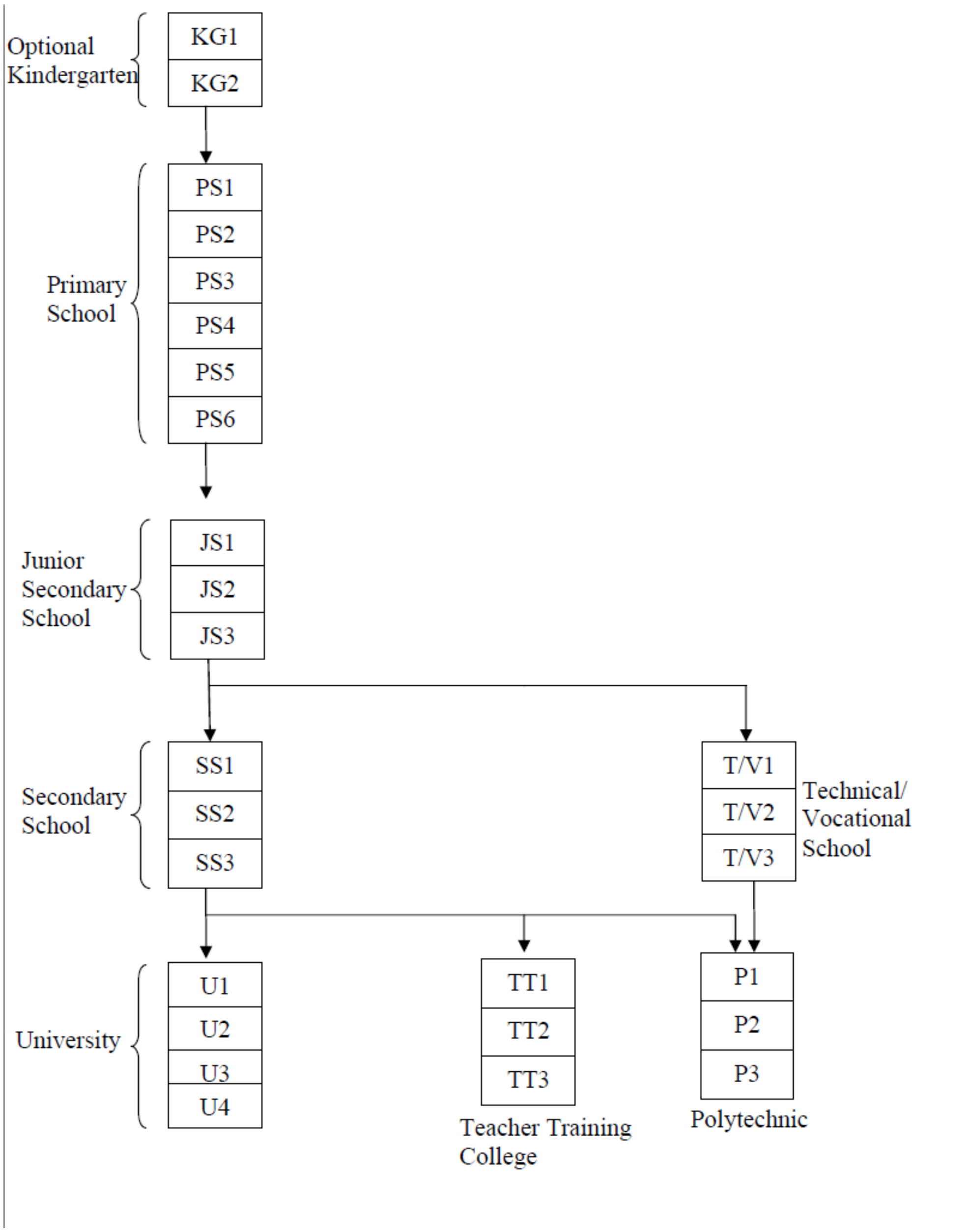
Appendix A Supplementary Figures

FIGURE A.1. Ghana's Structure of Education (After 1987)



Source: Akyeampong et al. (2007)

FIGURE A.2. Sample of Raven test

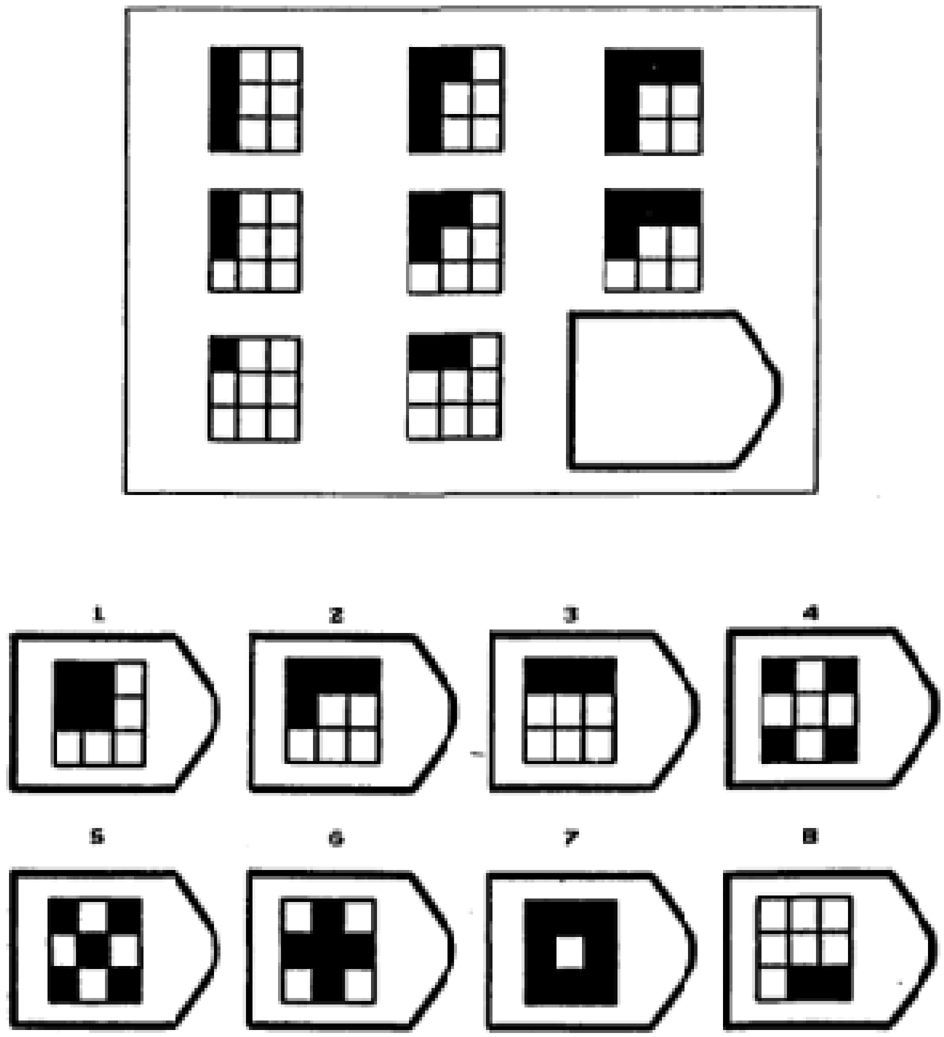


Figure 4a. A problem to illustrate the quantitative pairwise progression rule. The number of black squares in the top of each row increases by one from the first to the second column and from the second to the third column. The number of black squares along the left remains constant within a row, but changes between rows from three to two to one. (The correct answer is #3)

Appendix B Data Description

Appendix B.1 Main Data

Table B.1: Descriptive statistics of main variables, contemporaneous analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	(1) Total sample			(2) Primary			(3) Junior High			(4) Senior High		
	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.
Individual and HH variables												
Schooling outcomes												
Attendance	0.788	0.409	59120	0.815	0.388	31840	0.828	0.378	14959	0.669	0.471	12321
Grade-for-age	0.218	0.413	50073	0.316	0.465	26698	0.130	0.336	12734	0.077	0.266	10641
Shocks and controls												
Child age	11.089	3.393	59120	8.366	1.687	31840	12.917	0.817	14959	15.905	0.812	12321
Child is male	0.515	0.500	59120	0.512	0.500	31840	0.517	0.500	14959	0.519	0.500	12321
HH head is male	0.733	0.443	59023	0.746	0.435	31786	0.719	0.450	14938	0.714	0.452	12299
Real Cocoa Producers Price: 1987-2013												
Log(current real cocoa producer price)	13.798	0.391	27									

Source: GLLS1; and GLLS2; GLLS3; GLLS4; GLLS5 and GLLS6; Teal(2002) and Ghana Cocoa Board (sources of real Cocoa producer price). Samples for the controls are restricted to individuals for which information on schooling attendance is available.

Appendix B.2 Additional Data

Child labour data. To understand the mechanism behind the effects of variation in cocoa prices on schooling, we also use the same Ghana Living Standard Surveys (GLSS1, GLSS2, GLSS3, GLSS4, GLSS5 and GLSS6) and document the effect of current-year price fluctuations on child labour supply. We employ information indicating whether a child engages in any work; whether a child works in agricultural self-employment including contributing to family work; and if she participates in non-agricultural self-employment including contributing to a family business. Table B.3 presents summary statistics for these outcomes. Child labour appears to be a salient issue in our sample. Of the children in our sample, 31% engage in a type of work (either agricultural or non-agricultural work). Out of this, 21%, 37% and 45% are of the age of primary school, junior high school, and senior high school children, respectively. Moreover, in Table B.4, we also present summary statistics for adult labour supply outcomes that are used in a supporting analysis.

Table B.2: Descriptive statistics of main variables, early-life analysis

	(1)	(2)	(3)
	Mean	SD	Obs.
	Panel A: Raven/IQ Outcome		
Individual and HH variables			
Raven/IQ	48.968	18.201	2826
Child is male	0.515	0.5	2826
HH head is male	0.680	0.466	2826
Real Cocoa Producers Price: 1970-1994			
Log(Average early life cocoa producer price)	13.341	0.217	24
Log(In utero cocoa producer price)	13.384	0.346	24
	Panel B: Grade outcome		
Individual and HH variables			
Grade	2.94	2.941	49737
Child is male	0.515	0.5	49737
HH head is male	0.742	0.438	49640
Real Cocoa Producers Price: 1970-2007			
Log(Average early life cocoa producer price)	13.530	0.326	38
Log(In utero cocoa producer price)	13.515	0.372	38

Source: GLLS1; and GLLS2; GLLS3; GLLS4; GLLS5 and GLLS6(for Grade outcome);GLLS 2, 1989; and GEIES,2003 (for Raven/IQ outcome); Teal(2002) and Ghana Cocoa Board (sources of real Cocoa producer price)

Table B.3: Descriptive statistics of child labour supply outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	(1) Total sample			(2) Primary			(3) Junior High			(4) Senior High		
	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.
Child labour outcomes												
Any Work	0.309	0.462	54078	0.214	0.410	27327	0.371	0.483	14645	0.448	0.497	12106
Agri Work	0.289	0.453	54078	0.208	0.406	27327	0.349	0.477	14645	0.400	0.490	12106
Non-Agri Work	0.053	0.223	54078	0.028	0.164	27327	0.064	0.245	14645	0.095	0.294	12106

Source: GLLS1; and GLLS2; GLLS3; GLLS4; GLLS5 and GLLS6

Cocoa price data. Of key importance in Equations (1) and (2) is the way we measure cocoa price shocks and a child's exposure to such a shock. We use the series of real producer price of cocoa in Ghana provided by Teal (2002) and made public by the Centre for the

Study of African Economies. These data are particularly useful to measure the true and farm-gate (producer) price cocoa-growing households face. Teal (2002) computes the real producer price for cocoa exports as follows:

$$\frac{P_X^P}{P^C} = \frac{P_X}{P_M} \frac{P_M ER}{P^C} (1 - tax) \tag{1}$$

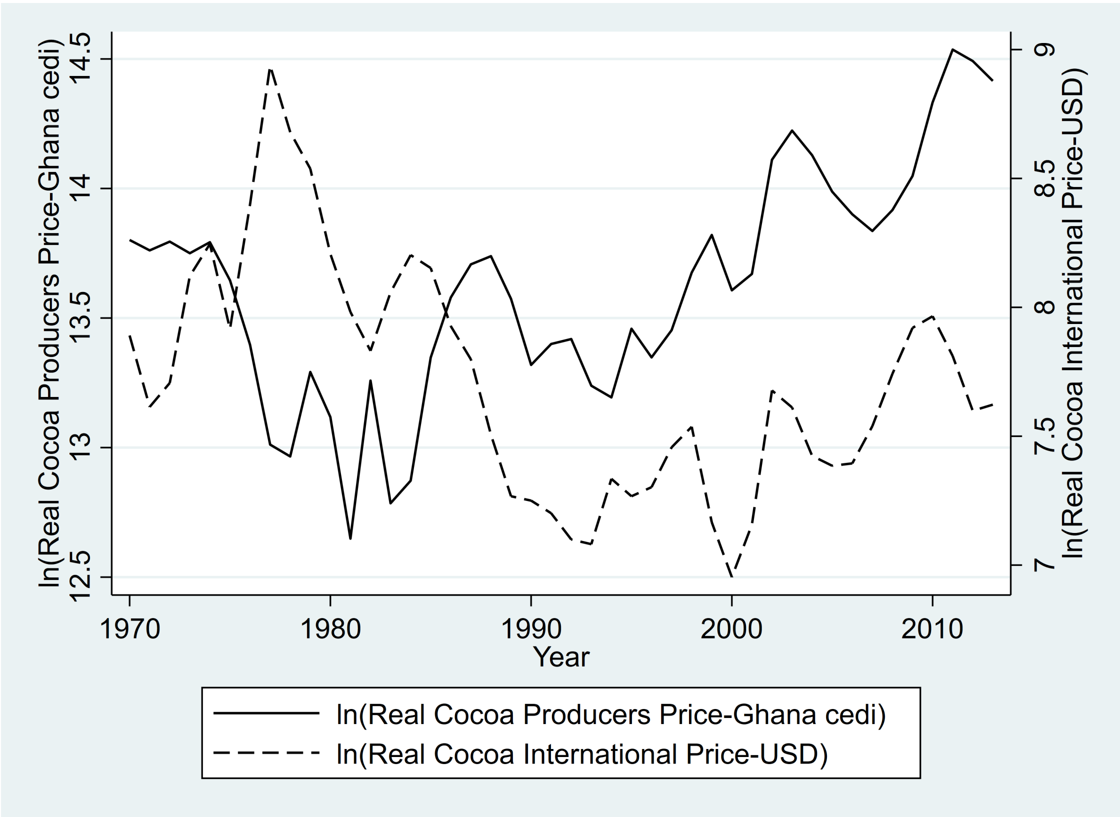
where, P_X^P is the cedi (Ghanaian currency) price received by cocoa producers. This price is then deflated by P^C, the price of domestic goods, to obtain the real producer price in cedi. Thus, the real producer price in cedi is a function of $\frac{P_X}{P_M}$, the export price in foreign currency divided by the price of imports in foreign currency, the official exchange rate, ER, and the tax rate, which encompasses both export duties and the difference between world cocoa prices and the lower prices often set by the monopolistic cocoa board. Table B.1 show descriptive statistics for the logarithm of the real producer price of cocoa for the contemporaneous analysis on child schooling and labour. For the subsequent analysis on cognitive development, descriptive statistics are shown in Table B.2. According to Table B.1, there is considerable variation in the price series in each sample. For instance, over the period between 1987 and 2013 (contemporaneous analysis), the standard deviation of the real producer price of cocoa is close to 0.39. Figure B.1 further contrasts this variation with that of the real international cocoa prices. These data are obtained from World Bank Commodity Markets for descriptive purposes.[1] With a coefficient of correlation of 0.27, Figure B.1 confirms the existence of a wedge between the real producer cocoa price and the international cocoa price. Such a wedge is mostly driven by taxation, the exchange rate and the limited capacity of the Cocoa Marketing Board (COCOCOB) to stabilize prices (Bulir, 1998). Figure B.1 also highlights a positive trend in real producer cocoa prices after 2000, covering the fifth and sixth living standard surveys.[2] Correlating real producer prices with schooling and cognitive outcomes

[1] See https://www.worldbank.org/en/research/commodity-markets.

[2] Figure B.2 depicts price data used specifically for the contemporaneous analysis (the series cover the years from 1987 to 2013). In the figure, the horizontal line represents the average price over the sample period and it is clear that the cocoa price shows a positive

may simply capture a confounding time effect or spurious trends. By comparing the effect of cocoa prices in cocoa-producing regions versus others with the means of a time and region fixed effects model, controlling (or not) for region-specific time trends, should minimize such an identification challenge. We further discuss this risk in Appendix D.4.

FIGURE B.1. Real Producer and International Price of Cocoa.

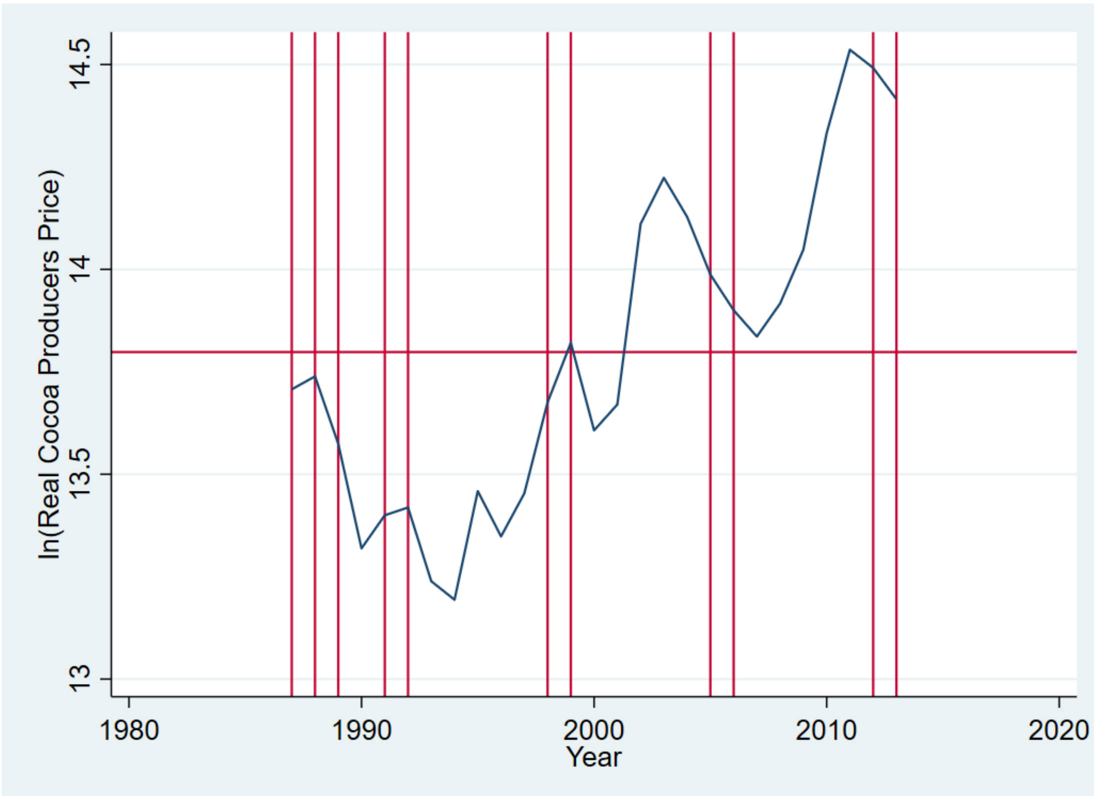


Source: Authors' computation using data from Teal(2002) and Ghana Cocoa Board; and World Bank

Cocoa production data. We exploit the EGC-ISSER Ghana Panel Survey conducted in 2009-2010 to construct an indicator for whether a region is defined as a cocoa producer. In the survey, individuals were asked to list all plots of land, the size of land in hectares, and the type of crops grown on these plots. Using this information, we calculate the total area of farmland in hectares by region. We also compute the total area of land occupied by cocoa, in hectares. Then, we compute the percentage of farmland occupied by cocoa by region as a fraction of the total farmland area. Figure B.3 shows, by region, the percentage of farm area

trend.

FIGURE B.2. Real Producer Price of Cocoa (Time Series) Used in the Contemporaneous Analysis. The vertical lines represent the interview years. The horizontal line shows the average price over the sample.

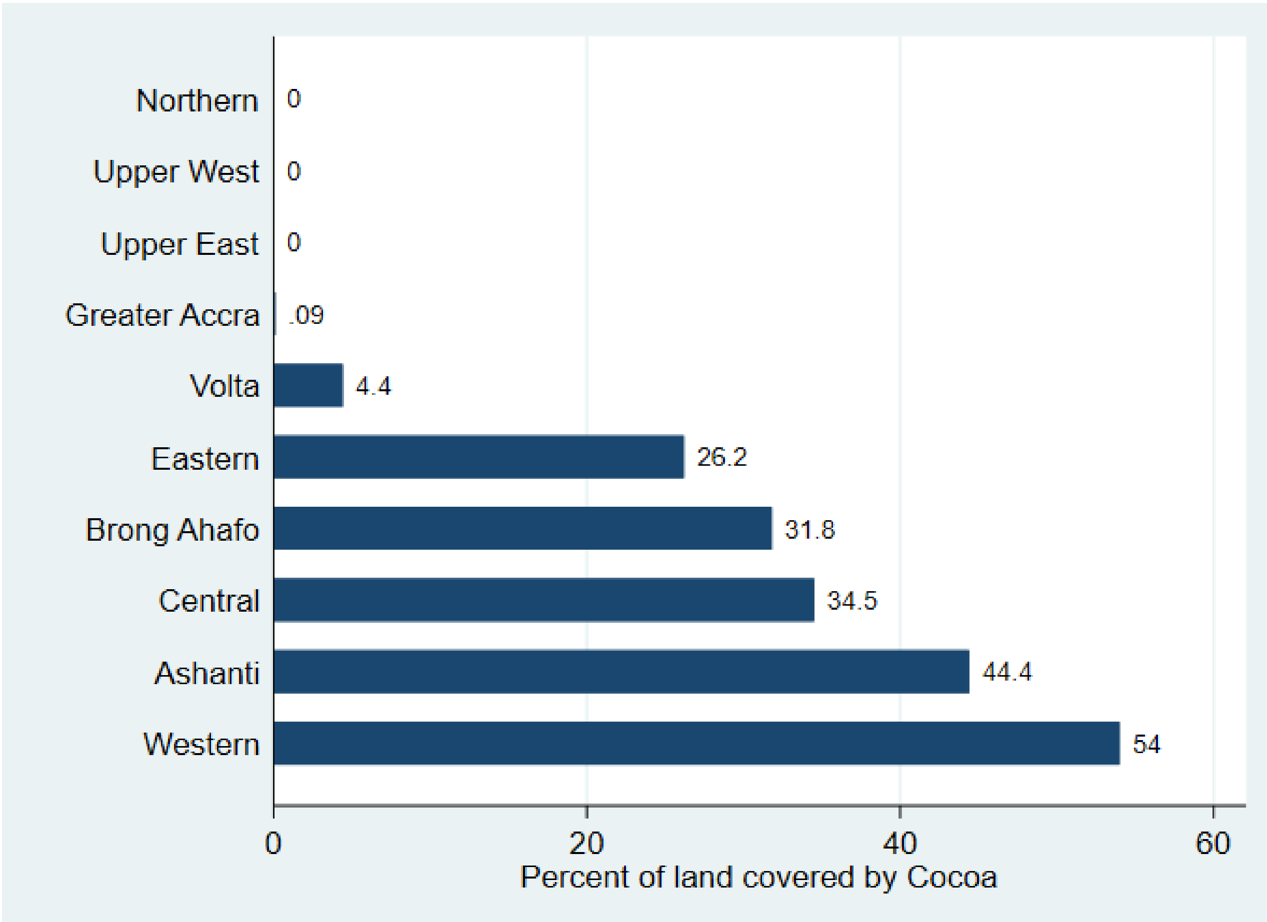


Source: Authors' computation using data from Teal(2002) and Ghana Cocoa Board

covered by cocoa. A region is treated as cocoa producing if the fraction is greater than 0%. In a robustness analysis, we drop regions with less than 20% of farmland occupied by cocoa (Greater Accra and Volta).

Other test scores. The Ghana Living Standards Survey Round 2 (GLSS2) and the Ghana Education Impact Evaluation Survey (GEIES) also collected information on achievement scores other than the Raven/IQ test, namely, simple English and maths tests. However, only a subset of household members who have three and more years of schooling were given the easy maths and easy reading tests. Moreover, those who scored 50 percent or more on these tests were asked to take advanced tests in English and maths. Panel B in Table B.4 reports summary statistics for these variables. These tests suffer from a sample selection problem, however. Therefore, we do not focus on these scores in the main analysis. We

FIGURE B.3. Fraction of farm area under Cocoa, by Region



Source: Authors' calculations using data from EGC-ISSER Socio-economic Panel Survey

believe that the effect of early-life shocks on these scores may be mediated by the impact of the shock on Raven/IQ scores and grade attainment. Thus, we use these tests to do back-of-the-envelope calculations to gauge the benefits obtained from early-life price booms that improved scores on the Raven/IQ test.

Health data for additional analyses. In addition to the main analyses, we also conduct several mediation and robustness analyses. For example, as a mediation analysis we explore the effect of contemporaneous price shocks on the health of mothers and the effect of early-life shocks on prenatal, at-birth and childhood investments. To that end, we use the Ghana Demographic and Health Surveys (GDHS) collected in 1988, 1993, 1998, 2003 and 2008. For the contemporaneous analysis of mothers' health, we exploit information on nationally representative samples of women aged 15-49 at the time of the survey. The data include information on a woman's year of birth, region of residence, years of education, rural residence, age, occupation, religion, ethnicity, height and weight. To investigate the effect of early-life shocks on prenatal, at-birth and childhood investments, we exploit information on every child aged up to 5 years of age at the time of the survey and born to women interviewed in the same survey. The data include information on children's characteristics such as year of birth, birth order, gender, current age in months; children vaccination histories and how long they are breastfed; and pregnancy and postnatal care and immunization carried out by the mother (such as prenatal visits to doctors, vaccines at-birth, and method of delivery of the child). Moreover, as a robustness check, we carry out mortality and fertility selection checks by exploiting information on every child ever born to women interviewed in the GDHS. Panel C in Table B.4 presents summary statistics for the outcomes from the GDHS.

Rainfall data. As further robustness checks, we also control for annual average rainfall, both in the contemporaneous and early-life analysis to minimize bias from potential omitted variables. The source for the data is the University of East Anglia Climatic Research Unit (UEA-CRU). Panel D in Table B.4 reports summary statistics for rainfall variables.

Table B.4: Descriptive statistics of additional variables

	(1)	(2)	(3)
	Mean	SD	N
	Panel A: Adult labour outcomes		
Any Work	0.823	0.381	84989
Agri. self employed or family work	0.521	0.500	84989
Non-Agri. self employed or family work	0.295	0.456	84989
	Panel B: Other test scores		
Simple reading	60.636	35.385	1375
Simple maths	60.686	25.187	1971
Advanced reading	48.432	19.041	596
Advanced maths	24.557	14.774	759
Panel C: GDHS, Individual's Recode, Children's Recode, Birth Recode			
Mother's health analysis (Individual's Recode)			
Mother Weight	57.677	12.205	14502
BMI	22.467	3.602	14075
Investment analysis (Children's Recode)			
No. of polio doses (max=3)	2.25	1.102	12743
No. of DPT doses (max=3)	2.235	1.146	12624
Measles	0.646	0.478	12598
No. total vaccination (max=7)	5.095	2.529	12762
No. months breastfeeding	14.923	8.675	16150
Mortality and fertility selection analysis (Birth Recode)			
Child is boy	0.511	0.5	67676
Mother year of education	3.908	5.019	67656
Age of mother	36.128	7.803	67676
Height of mother	173.544	110.202	42383
No births	5.38	2.606	67676
Husband in self employed agriculture	0.584	0.493	66463
	Panel D: Rainfall data		
For Contemporaneous analysis			
Mean annual rainfall	103.495	17.685	110
For Grade Outcome			
Mean annual rainfall (early life)	103.471	15.533	380
Mean annual rainfall (in utero)	103.172	19.578	380
For Raven/IQ Outcome			
Mean annual rainfall (early life)	103.733	15.92	240
Mean annual rainfall (in utero)	104.068	20.832	240

Source: GLLS1, GLLS2, GLLS3, GLLS4, GLLS5 and GLLS6 for the contemporaneous analysis in the case of child labour outcomes; GLLS2 and GEIES for the analysis on other test scores; rainfall data from University of East Anglia Climatic Research Unit (UEA-CRU); GDHS 1988 1993, 1998, 2003 and 2008 for mother's health, investment, and mortality and fertility analyses)

Appendix C Additional analysis

Appendix C.1 International price Instruments: First stage results

Table C.1: Exploiting international price as Instrument(IV): First stage results

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Second stage outcome: Current Attendance			
	First stage outcome: Cocoa Price × Cocoa Producer Region			
	Panel A: without region-specific trends			
International Cocoa Price × Cocoa Producer Region	1.254***	1.246***	1.264***	1.270***
	(0.020)	(0.019)	(0.021)	(0.017)
Observations	58,568	31,533	14,829	12,206
KP Wald F statistic	4039.737	4145.335	3537.045	5887.884
	Panel B: with region-specific trends			
International Cocoa Price × Cocoa Producer Region	0.728***	0.716***	0.745***	0.749***
	(0.028)	(0.030)	(0.022)	(0.022)
KP Wald F statistic	2400.073	1932.346	2103.866	10000
Observations	58,568	31,533	14,829	12,206
	Second stage outcome: Grade-for-age			
	First stage outcome: Cocoa Price × Cocoa Producer Region			
	Panel C: without region-specific trends			
International Cocoa Price × Cocoa Producer Region	1.234***	1.239***	1.237***	1.211***
	(0.025)	(0.028)	(0.027)	(0.012)
KP Wald F statistic	697.083	572.102	1130.290	1123.556
Observations	49,621	26,451	12,629	10,541
	Panel D: with region-specific trends			
International Cocoa Price × Cocoa Producer Region	0.619***	0.624***	0.619***	0.604***
	(0.020)	(0.025)	(0.018)	(0.010)
KP Wald F statistic	932.412	638.491	1190.030	3828.087
Observations	49,621	26,451	12,629	10,541
Region of Birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Year of Birth FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Survey weights are used in the regression estimations.

Table C.2: Exploiting international price as an IV, first stage, early life

	Age 9 to 17		Age 6 to 17	
	(1)	(2)	(3)	(4)
	2nd stage outcomes:			
	Raven/IQ	Raven/IQ	Grade	Grade
	Panel A: 1st stage outcome: Early-life Cocoa Price × Cocoa Producer Region			
Early-life Int.Cocoa Price × Cocoa Producer Region	-0.379***	-0.454***	-0.519	-0.249**
	(0.011)	(0.0118)	(0.031)	(0.031)
KP Wald F statistic	1172.031	1471.507	273.489	63.226
Observations	2,826	2,826	49,621	49,621
	Panel B: 1st stage outcome: In-utero Cocoa Price × Cocoa Producer Region			
In-utero Int.Cocoa Price × Cocoa Producer Region	-0.307***	-0.300***	-0.412***	-0.298***
	(0.015)	(0.019)	(0.018)	(0.024)
KP Wald F statistic	309.691	255.469	519.075	154.565
Observations	2,826	2,826	49,621	49,621
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region of birth trends	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child and gender of household head. The Raven/IQ includes children of ages 9 to 17, while grade is reported for children of age 6 to 17. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

Appendix C.2 Details and additional analysis of child labour

In this section, we discuss in detail the effects of price shocks on child labour outcomes to shed light on a possible substitution effect. First, using employment in the last 12 months, we assess the effect of a current-year cocoa price shock on child labour supply (work in agricultural and non-agricultural activities).[3]

[3] In most GLSS surveys, employment outcomes are assessed for both definitions of participation in the labour market: employment in the last 7 days or in the last 12 months. However, the GLSS3 and GLSS4 surveys focus on surveying employment and activity status

Table C.4 presents the effect of a shock on the likelihood of a child engaging in any work (panel A); the probability of a child working in agricultural self-employment, including contributing to family work (panel B); and the likelihood that she participates in non-agricultural self-employment, including contributing to a family business (panel C). The results in Table C.4 show that during a cocoa price boom, children engage in significantly more work. In regions that produce cocoa, an increase in the current-year real cocoa price increases any form of employment for all groups of children (panel A, columns 1 to 4). In panel B, we also find evidence that higher current-year prices lead into more work in the agricultural sector, especially for the whole sample and for older children. In Panel C, we also find evidence that current year higher prices result into more work in non-agricultural sector.[4]

We also estimate the effects of current-year cocoa price fluctuations on the adult labour supply to economic activities. The results are presented in the first three columns of Table C.7. A price boom is significantly associated with higher labour supply to any type of employment by adults. This is further suggestive evidence that in a coca price boom, household income improves due to higher employment.

The results regarding the effect of price shocks on labour supply outcomes only capture the extensive margin of labour supply. As a result, they may underestimate the full effect of a price boom. Nonetheless, the results provide suggestive evidence that during a cocoa price boom, economic activities flourish in cocoa producing regions.

in the last 12 months. This led us to use the 'last 12 months' definition of employment in our analysis. Moreover, using the last 12 months as a basis for the employment definition is also advantageous to account for seasonality, which is one of the characteristics of labour markets in low-income countries. To be consistent with this definition of employment status, we also report the effect of a shock on attendance in the last 12 months in Table C.6. The results are virtually similar to Table 1 (in the main article).

[4]Similar results are found when using international prices as an instrumental variable (Table C.5).

Appendix C.3 Auxiliary analysis: The effect of Raven test on other tests

Table C.3: The effect of Raven test on other tests

	(1) Simple reading	(2) Simple math	(3) Advanced reading	(4) Advanced math
Raven	0.600***	0.476***	0.275***	0.148***
	(0.043)	(0.028)	(0.041)	(0.033)
Observations	1,359	1,953	566	625
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes	Yes
Child Controls	Yes	Yes	Yes	Yes

Robust standard errors in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child and gender for household head. The source of data is self weighted.

Appendix C.4 How do early-life shocks affect cognitive development?

It is plausible that the positive effects of prenatal price shocks on cognition and grade may be due to improvement in nutritional intake in utero, as a result of improved household income. Indeed, access to nutrition in utero is critical for health and human capital development (Barker, 1990). Empirical evidence such as that provided by Hoynes et al. (2011) and Hoynes et al. (2016) for the USA and Black et al. (2007) for Norway show that both short-term and long-term health and socio-economic outcomes are significantly impacted by access to nutrition in utero. To explore this mechanism, similar to Adhvaryu et al. (2019), we estimate whether the health of mothers responds to contemporaneous price shocks, using the GDHS (1993, 1998, 2003 and 2008). An increase in contemporaneous price can improve a mother's weight and BMI by increasing consumption. We show that an increase in the current real price of cocoa improves the weight and BMI of mothers (Table C.8). This can be taken as suggestive evidence that children conceived during a cocoa price boom might receive better nutrition in utero.

Another explanation might be that an increase in the real producer price of cocoa raises household income and relaxes budget constraints. This improvement in the available resources for the household may lead to investment in better prenatal care, delivery and other at-birth investments such as vaccinations. To investigate whether this is the case in Ghana, using the GDHS (1988, 1993, 1998, 2003 and 2008) we estimate the effects of price shocks before the year of birth on prenatal and at-birth investment. The results are presented in panel A of Table C.9. Column (1) presents estimates on whether the mother had doctor-assisted prenatal care; column (2), whether the mother had a doctor-assisted delivery; column (3), whether the child received the BCG vaccine (for tuberculosis); and column (4), whether the child received a polio 0 dose vaccination. There is no significant evidence that an increase in real cocoa prices improves prenatal and at-birth investments. In 2004, the Ghanaian government implemented the National Health Insurance Scheme (NHIS) (Mensah et al., 2010; Bonfrer et al., 2016). This insurance programme was implemented to solve the problem of high medical treatment costs faced by Ghanaians. Pregnant mothers who need ante-natal, delivery and post-natal health care services are among the beneficiaries of the NHIS. The results presented here using the GDHS (1988, 1993, 1998, 2003 and 2008) may not tell us the pure effects that stem from relaxed budget constraints from increased household income, because the data also contain information from after the implementation of the NHIS. Table C.10 reports results excluding the 2008 GDHS (data collected after the implementation of the NHIS). The results remain the same. Furthermore, parents may respond to children's endowments by investing either in a compensatory or reinforcing manner (Adhvaryu and Nyshadham, 2016). To test for this parental investment behaviour, we estimate the effect of in utero price shocks on childhood investments. Panel B of Table C.9 reports these results. Column (1) presents estimates on the number of polio doses; column (2), on the number of DPT doses; column (3), on measles vaccination; column (4), on the number of vaccines; and column (5), on the number of months of breastfeeding. Price shocks have significant positive effects on most of these investments: an in utero increase in price leads to higher childhood investments. Similar to Adhvaryu and Nyshadham (2016) and Adhvaryu et al. (2019), we find evidence that parents in Ghana reinforce children's endowment through further childhood investments later in infancy. This implies that the positive and significant effect on cognition and grade attainment found in the previous analysis could stem from childhood investments in addition to improved nutrition.

Appendix C.5 Do early-life shocks and school-aged shocks persist?

In theory, we would like to observe whether children who leave or delay school to work during cocoa price booms return or not in later periods. This would help us understand whether the effects persist. Unfortunately, we do not have panel data following children over time. As an alternative, we use the total years of schooling attained as an adult to investigate whether school-age (also early-life) price shocks have long-term effects on adult years of schooling. If the effect persists, adulthood years of schooling would be negatively related with school-age prices and positively related with higher early-life and in utero prices. Our sample is constructed from 2000 and 2010 Ghana census data on individuals 18–60 years of age at the time they are observed in the census. Table C.11 shows that cohorts exposed to higher average early life prices attain more years of schooling as adults. Moreover, cohorts exposed to higher average school-age prices attain fewer years of schooling as adults. Carrillo (2020) also documents similar effects from coffee prices in Colombia. This suggests that the effects of early-life and school-age price shocks persist to have an impact on adult human capital accumulation.

Table C.4: Estimated effect of current-year cocoa price shock on child labour

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Any Work			
Cocoa Price × Cocoa Producer Region	0.335*	0.257*	0.359*	0.450*
	(0.109)	(0.123)	(0.123)	(0.122)
	[0.060]	[0.075]	[0.070]	[0.059]
Observations	53,596	27,076	14,522	11,998
	Panel B: Agri. self emp't or contributing to family work			
Cocoa Price × Cocoa Producer Region	0.208*	0.171	0.177	0.280*
	(0.088)	(0.106)	(0.099)	(0.100)
	[0.087]	[0.167]	[0.139]	[0.068]
Observations	53,596	27,076	14,522	11,998
	Panel C: Non-Agri. self emp't or contributing to family business			
Cocoa Price × Cocoa Producer Region	0.075*	0.042	0.108**	0.116*
	(0.035)	(0.022)	(0.046)	(0.062)
	[0.058]	[0.123]	[0.044]	[0.062]
Observations	53,596	27,076	14,522	11,998
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Panel A reports results on any work, and panel B shows the effect of price shock on agricultural employment and panel C shows the effect of price shock on non-agricultural employment. Survey weights are used in the regression estimations.

Table C.5: Estimated effect of current-year cocoa price shock on child labour: IV second stage

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Any Work			
Cocoa Price × Cocoa Producer Region	0.473**	0.319*	0.536**	0.705**
	(0.114)	(0.135)	(0.127)	(0.104)
	[0.033]	[0.058]	[0.030]	[0.033]
Observations	53,596	27,076	14,522	11,998
	Panel B: Agri. self emp't or contributing to family work			
Cocoa Price × Cocoa Producer Region	0.286	0.196	0.292	0.434*
	(0.109)	(0.122)	(0.152)	(0.120)
	[0.103]	[0.156]	[0.214]	[0.090]
Observations	53,596	27,076	14,522	11,998
	Panel C: Non-Agri. self emp't or contributing to family business			
Cocoa Price × Cocoa Producer Region	0.118**	0.062**	0.151**	0.203**
	(0.032)	(0.017)	(0.054)	(0.061)
	[0.016]	[0.041]	[0.028]	[0.029]
Observations	53,596	27,076	14,522	11,998
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Panel A reports results on any work, and panel B shows the effect of price shock on agricultural employment and panel C shows the effect of price shock on non-agricultural employment. Survey weights are used in the regression estimations.

Table C.6: Estimated effect of current-year cocoa price shock on school attendance over the last 12 months

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Last 12 Months Attendance			
Cocoa Price × Cocoa Producer Region	-0.154**	-0.228**	-0.064	-0.056
	(0.066)	(0.070)	(0.064)	(0.103)
	[0.020]	[0.028]	[0.396]	[0.718]
Observations	58,593	31,547	14,835	12,211
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): gender of the child, child age, and gender of household head. Survey weights are used in the regression estimations.

Table C.7: Estimated effect of current-year cocoa price shock on adult labour supply

	(1) Any work	(2) Agri. self emp. or family	(3) Non-agri. self or family
Cocoa Price × Cocoa Producer Region	0.159**	0.166	0.067
	(0.068)	(0.075)	(0.068)
	[0.028]	[0.116]	[0.469]
Observations	83,803	83,803	83,803
Region of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): gender, age, and gender of household head. Column (1) reports results on any work, and column (2) shows the effect of price shock on agricultural employment, and column (3) shows the effect of price shock on non-agricultural employment. Survey weights are used in the regression estimations.

Table C.8: Estimated health effect of contemporaneous cocoa price shock on mothers' health

	(1) Mother weight	(2) Mother BMI
Cocoa Price × Cocoa Producer Region	4.098**	0.972*
	(0.865)	(0.290)
	[0.016]	[0.056]
Observations	14,472	14,045
Region FE	Yes	Yes
Survey Year FE	Yes	Yes
Region time trends	Yes	Yes
Controls	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Mother education, rural, age of mother, dummies for Ethnicity and religion. Survey weights are used in the regression estimations.

Table C.9: Estimated health effect of in utero cocoa price shock on investments

	(1)	(2)	(3)	(4)	(5)
	Panel A: Prenatal/at-birth investments				
	Doctor assist prenatal care	Doctor assist delivery	Received BCG	Received Polio 0 dose	
In-utero Cocoa Price × Cocoa Producer Region	0.121	0.024	0.072	0.066	
	(0.054)	(0.021)	(0.023)	(0.161)	
	[0.236]	[0.355]	[0.166]	[0.722]	
Observations	11,798	13,322	11,905	9,101	
	Panel B: Childhood investments				
	No. of polio doses	No. of DPT doses	Measles	No. of total vaccinations	Months of breastfeeding
In-utero Cocoa Price × Cocoa Producer Region	0.361*	0.422*	0.010	0.741*	2.004
	(0.070)	(0.079)	(0.028)	(0.195)	(1.563)
	[0.064]	[0.053]	[0.701]	[0.059]	[0.592]
Observations	11,962	11,853	11,825	11,980	13,152
Region of birth FE	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Household size, birth order, mother education, rural, gender of child, and dummies for ethnicity and religion. Panel A presents results on childhood investments and panel B focuses results on birth investments. Survey weights are used in the regression estimations.

Table C.10: Estimated health effect of in utero cocoa price shock on investments, excluding 2008 GDHS

	(1)	(2)	(3)	(4)	(5)
	Panel A: Prenatal/at-birth investments				
	Doctor assist prenatal care	Doctor assist delivery	Received BCG	Received Polio 0 dose	
In-utero Cocoa Price × Cocoa Producer Region	0.152	0.001	0.163	-0.078	
	(0.072)	(0.027)	(0.065)	(0.161)	
	[0.169]	[0.974]	[0.142]	[0.680]	
Observations	9,798	10,642	9,236	6,421	
	Panel B: Childhood investments				
	No. of polio doses	No. of DPT doses	Measles	No. of total vaccinations	Months of breastfeeding
In-utero Cocoa Price × Cocoa Producer Region	0.588**	0.555*	-0.083	0.889*	4.747**
	(0.105)	(0.151)	(0.092)	(0.392)	(0.797)
	[0.040]	[0.083]	[0.701]	[0.086]	[0.033]
Observations	9,287	9,188	9,155	9,302	10,530
Region of birth FE	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Household size, birth order, mother education, rural, gender of child, and dummies for ethnicity and religion. Panel A presents results on childhood investments and panel B focuses results on birth investments. Survey weights are used in the regression estimations.

Table C.11: Estimated long-term effect of early-life and school-age shocks

	(1) Years of Schooling	(2) Years of Schooling	(3) Years of Schooling
Early-life Cocoa Price × Cocoa Producer Region	0.494**		
	(0.121)		
	[0.026]		
In-utero Cocoa Price × Cocoa Producer Region		0.351**	
		(0.087)	
		[0.039]	
School-age Cocoa Price × Cocoa Producer Region			-1.128***
			(0.297)
			[0.006]
Observations	2,073,558	2,073,558	2,073,558
Region of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample is constructed from 2000 and 2010 Ghana census data on individuals who are 18–60 years old at the time they are observed in the census. School-age cocoa price of the cohort born in year t is the average real producer cocoa price observed between age 6 to age 17. Early life cocoa price of the cohort born in year t is the average real producer cocoa price observed between in utero to age 2. Controls include (X): rural, gender of child, and gender of household head.

Appendix D Robustness

Appendix D.1 Alternative instruments

Our specifications which employ world prices as alternative prices or as instruments may not totally alleviate the concern that given the importance of Ghana as a leading cocoa exporter, the world price – and thereby the producer price – may not be exogenous. To assess the robustness of our results, we may still need to find other exogenous variation to use as an instrument for the producer price of cocoa. Cocoa production is mostly a function of weather conditions (Lass and Wood, 1985; Ruf et al., 2015; Schroth et al., 2016). As pointed out by Behrman (1968, p. 703), 'A mean shade temperature of approximately 80 degrees Fahrenheit with variations not more than +/- 15 degrees, a well-distributed rainfall of at least 50 inches annually, an altitude between a few hundred feet and a thousand feet above sea level, and protection from strong winds are all usually required.'[5] Based on the vulnerability of cocoa beans to weather shocks, we provide alternative instrumental variables as further robustness checks. First, we identify major cocoa exporters over our sample period. In the period that we consider for the contemporaneous analysis, we identify Cameroon, Nigeria, Indonesia, the Netherlands and Ivory Coast as the top cocoa exporters besides Ghana. For the early-life sample period, Cameroon, Nigeria, Ivory Coast, Brazil and Indonesia/Malaysia are major exporters. We then exploit the occurrence of natural disasters and weather shocks in these countries as exogenous variation that may influence the global cocoa supply, and as a result,

[5] These required ecological conditions explain why cocoa production is concentrated in a few tropical countries. Already in the early sixties, five countries – namely Ghana, Nigeria, Ivory Coast, Cameroon, and Ecuador – were reported to account for 78 percent of the global supply (Behrman, 1968). Today (as of 2019 or averaged over 2010-2019, based on the Food and Agriculture Organisation (FAO) data), the same five countries remain the five largest producer countries. Adding Brazil, the Dominican Republic and Venezuela, Behrman (1968) reported that these eight countries accounted for 86 percent of all exports in the early sixties. The equivalent with updated FAO data would give a share of 87 percent. The composition of the main exporters has remained relatively stable over time, even if new countries like Malaysia and Indonesia have increased their market shares since the sixties.

cocoa producer prices.[6]

In Tables D.1 and D.2, we report results from instrumental variable estimations. In both tables, panels A and C show the second-stage estimations, while panels B and D report the first-stage estimations. As illustrated in panels B and D, the first-stage estimates in both analyses predict strong and significant relationships with the endogenous variables. Importantly, the results in the contemporaneous analysis are largely similar to the OLS results. Higher prices decrease attendance and grade-for-age, in particular for primary school children. Similarly, the instrumental variable estimation confirms the positive effect of early-life shocks on cognitive development and grade outcomes.

[6]More specifically, we instrument the main variable of interest ($\text{CocoaPrice}_t \times \text{CocoaProducer}_r$) by the interaction between the occurrence of natural disasters or a measure of weather shocks and the variable indicating whether coca is produced in the concerned region ($\text{DisasterShock}_t \times \text{CocoaProducer}_r$ or $\text{WeatherShock}_t \times \text{CocoaProducer}_r$). In the early-life analysis, the subscript t is replaced by the subscript $y - 1$. To implement these checks, we first use data from the International Disaster Database to identify drought, flood, extreme temperature and wildfire as disaster events that determine cocoa production and prices (see https://www.emdat.be/database). Then we construct the number of events of each disaster type (drought, flood, wildfire, and extreme temperature) occurring in the major cocoa exporter countries by calendar year as potential instrument variables. DisasterShock_t is the total number of a particular type of disaster occurring in a given year in the major cocoa exporter countries. $\text{DisasterShock}_{y-1}$, on the other hand, represents the total number of events of a given disaster type that occurred in the major cocoa exporter countries in an individual's early life. To construct alternative instrumental variables based on weather shocks, we use data from the World Bank and construct rainfall and temperature anomalies (see https://climateknowledgeportal.worldbank.org/download-data). WeatherShock_t and $\text{WeatherShock}_{y-1}$ represent these variables.

Table D.1: IV Estimated effect of current and previous year cocoa price shock on schooling

	Event IV				Weather IV			
	All	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)	All	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Current Attendance, Second-Stage							
Cocoa Price × Cocoa Producer Region	-0.156*	-0.209**	-0.100	-0.068	-0.218**	-0.302***	-0.198	-0.017
	(0.077)	(0.079)	(0.088)	(0.084)	(0.083)	(0.082)	(0.114)	(0.119)
	[0.051]	[0.048]	[0.292]	[0.533]	[0.027]	[0.004]	[0.202]	[0.879]
Observations	58,568	31,533	14,829	12,206	58,568	31,533	14,829	12,206
	Panel B: Cocoa Price × Cocoa Producer Region, First-Stage							
Drought	0.291***	0.291***	0.301***	0.275***				
	(0.023)	(0.022)	(0.019)	(0.028)				
Flood	0.024***	0.024***	0.026***	0.022***				
	(0.003)	(0.003)	(0.003)	(0.003)				
Wildfire	-0.163***	-0.160***	-0.163***	-0.174***				
	(0.016)	(0.016)	(0.014)	(0.020)				
Extreme temp	-0.129***	-0.132***	-0.132***	-0.117***				
	(0.015)	(0.015)	(0.013)	(0.018)				
Rainfall anomalies					0.148***	0.146***	0.156***	0.146***
					(0.012)	(0.013)	(0.010)	(0.008)
Temperature anomalies					-0.212***	-0.209***	-0.216***	-0.217***
					(0.007)	(0.007)	(0.007)	(0.007)
KP Wald F statistic	180000	120000	150000	280000	470.932	464.490	553.628	648.781
Observations	58,568	31,533	14,829	12,206	58,568	31,533	14,829	12,206
	Panel C: Grade-for-age, Second-Stage							
Cocoa Price × Cocoa Producer Region	-0.131***	-0.203***	-0.029	-0.050	-0.034	-0.075	-0.064	0.056
	(0.027)	(0.038)	(0.028)	(0.050)	(0.046)	(0.064)	(0.051)	(0.069)
	[0.004]	[0.006]	[0.387]	[0.404]	[0.559]	[0.343]	[0.369]	[0.499]
Observations	49,621	26,451	12,629	10,541	49,621	26,451	12,629	10,541
	Panel D: Cocoa Price × Cocoa Producer Region, First-Stage							
Drought	0.284***	0.284***	0.296***	0.268***				
	(0.025)	(0.024)	(0.020)	(0.031)				
Flood	0.029***	0.030***	0.031***	0.027***				
	(0.002)	(0.002)	(0.003)	(0.002)				
Wildfire	-0.189***	-0.187***	-0.189***	-0.198***				
	(0.023)	(0.023)	(0.019)	(0.026)				
Extreme temp	-0.106***	-0.108***	-0.109***	-0.095***				
	(0.021)	(0.021)	(0.018)	(0.024)				
Rainfall anomalies					0.172***	0.172***	0.180***	0.164***
					(0.009)	(0.010)	(0.009)	(0.008)
Temperature anomalies					-0.215***	-0.214***	-0.217***	-0.217***
					(0.004)	(0.004)	(0.005)	(0.005)
KP Wald F statistic	130000	96000	230000	230000	182.929	112.345	502.565	516.568
Observations	49,621	26,451	12,629	10,541	49,621	26,451	12,629	10,541
Region of birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Survey weights are used in the regression estimations.

Table D.2: IV Estimated effect of early-life and in utero cocoa price shock on cognition

	Event IV		Weather IV	
	(1) Raven/IQ	(2) Grade	(3) Raven/IQ	(4) Grade
	Panel A: Early life second-stage			
Early-life Cocoa Price × Cocoa Producer Region	10.213	1.304**	24.951**	0.400
	(5.642)	(0.214)	(9.378)	(0.199)
	[0.285]	[0.017]	[0.031]	[0.153]
Observations	2,525	49,551	2,826	49,551
	Panel B: Early-life Cocoa Price × Cocoa Producer Region, first-stage dependent variable			
Drought early	-0.712***	-0.015		
	(0.030)	(0.016)		
Flood early	0.259***	0.039***		
	(0.004)	(0.001)		
Extreme temp early	-0.037	0.551***		
	(0.029)	(0.017)		
Wildfire early	0.278***	0.018***		
	(0.022)	(0.003)		
Rainfall anomalies early			-0.029***	0.149***
			(0.004)	(0.005)
Temperature anomalies early			0.189***	0.064***
			(0.012)	(0.006)
KP Wald F statistic	38000	160000	120.927	557.276
Observations	2,525	49,551	2,826	49,551
	Panel C: In-utero Second-stage			
In-utero Cocoa Price × Cocoa Producer Region	-5.060	1.517**	26.392	-0.087
	(6.276)	(0.211)	(10.586)	(0.218)
	[0.576]	[0.011]	[0.196]	[0.718]
Observations	2,525	49,551	2,826	49,551
	Panel D: In-utero Cocoa Price × Cocoa Producer Region, first-stage dependent variable			
Drought in utero	-0.175***	-0.006		
	(0.022)	(0.005)		
Extreme temp in utero	-0.062***	0.158***		
	(0.009)	(0.009)		
Flood in utero	0.071***	0.001		
	(0.008)	(0.002)		
Wildre in utero		0.023***		
		(0.005)		
Rainfall anomalies in utero			0.089***	0.108***
			(0.006)	(0.003)
Temperature anomalies in utero			0.102***	0.096***
			(0.003)	(0.005)
KP Wald F statistic	1165.513	14000	1818.698	866.288
Observations	2,525	49,551	2,826	49,551
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. Wild-bootstrap p-values in brackets. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child and gender of household head. The Raven/IQ includes children of ages 9 to 17, while grade is reported for children of age 6 to 17. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

Appendix D.2 Confounding weather shocks

Contemporaneous rainfall shocks are associated with schooling outcomes (Jensen, 2000; Shah and Steinberg, 2017). Studies like Shah and Steinberg (2017), Maccini and Yang (2009), and Thai and Falaris (2014) also provide evidence that in utero and early childhood rainfall shocks determine later childhood and long-term adulthood human capital outcomes. Since cocoa is an agricultural crop, rainfall variability impacts its yield and, hence, its price. As a result, the baseline results might suffer from omitted-variable bias. In that case, the results might be due to fluctuations in rainfall and the established effect might be due to the fact that rainfall was not included in the regressions. We re-estimate equation 1 (in the main article) including contemporaneous annual average rainfall in the contemporaneous analysis and early-life rainfall in the early-life analysis. The results are reported in Tables D.3 and D.4. Controlling for rainfall does not alter the baseline results.

Table D.3: Controlling for rainfall, contemporaneous

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Current Attendance			
Cocoa Price × Cocoa Producer Region	-0.217*	-0.281**	-0.137	-0.124
	(0.061)	(0.055)	(0.066)	(0.107)
	[0.051]	[0.029]	[0.110]	[0.294]
Mean annual rainfall by region	-0.000	-0.001	-0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	58,568	31,533	14,829	12,206
	Panel B: Grade-for-age			
Cocoa Price × Cocoa Producer Region	-0.133**	-0.233***	0.010	-0.018
	(0.038)	(0.046)	(0.038)	(0.067)
	[0.021]	[0.000]	[0.804]	[0.812]
Mean annual rainfall by region	-0.000	0.000	-0.001	-0.002*
	(0.000)	(0.001)	(0.001)	(0.001)
Observations	49,621	26,451	12,629	10,541
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Mean annual rainfall at region of survey level, gender of the child, child age, and gender of household head. Panel A reports results on current attendance, panel B shows the effect of price shock on grade-for-age. Survey weights are used in the regression estimations.

Appendix D.3 Mortality and Fertility Selection

The sample used to assess the effect of early-life shocks is composed of surviving children. An economic slump in utero may result in a higher probability of in utero death, however. Surviving children included in the sample may, as a result, be the strongest and the healthiest. This mortality selection would drive the baseline estimates towards zero and, as a result, may not be a concern. Generally, one might expect that exposure to positive economic shocks

Table D.4: Controlling for rainfall, early-life and in utero

	Age 9 to 17	Age 6 to 17
	(1)	(2)
	Raven/IQ	Grade
	Panel A: Effects of average early-life price shocks	
Early-life Cocoa Price × Cocoa Producer Region	12.936*	1.398**
	(5.074)	(0.206)
	[0.085]	[0.017]
Early-life rainfall by region	-0.036	-0.017
	(0.067)	(0.012)
Observations	2,826	49,621
	Panel B: Effects of in utero price shock	
In-utero Cocoa Price × Cocoa Producer Region	10.384**	1.097**
	(3.286)	(0.116)
	[0.046]	[0.010]
In-utero rainfall by region	0.055	-0.001
	(0.036)	(0.002)
Observations	2,826	49,621
Region of birth FE	Yes	Yes
Year of birth FE	Yes	Yes
Survey year FE	Yes	Yes
Region of birth trends	No	Yes
Controls	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Mean annual rainfall at region of birth level, gender of the child and gender of household head. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

(booms) at a prenatal stage does not reduce the number of live births (Hoynes et al., 2016). But one can also argue that a price boom may increase in utero (infant) mortality if pregnant women (mothers) work more in the cocoa sector, to take advantage of the boom, instead of devoting time to prenatal (child) care (Miller and Urdinola, 2010). Indeed, we find that during a cocoa price boom, women (mothers) work more (Table D.5). If a cocoa price boom results in prenatal death, those who escaped death and were born may be the strongest and healthiest. The results in the baseline would thus be biased in the upward direction. This selection is a concern.

In Table D.6, we assess the impact of utero price shocks on miscarriage (column 1), the probability of a boy birth (column 2) and neonatal death (column 3).[7] In column (1), we show that a price boom does not significantly increase miscarriage. Column 2 does not show any effect on the probability of having a boy. In other words, a cocoa price boom does not significantly affect the sex ratio.[8] Moreover, price booms do not result in a significant effect on neonatal death (column 3). In conclusion, mortality selection in utero does not seem to be an issue for the baseline results.

The other selection issue of concern for the early-life analysis is related to fertility. Women may prefer to conceive and give birth during boom years, and these planned children may grow up to achieve better cognition and more years of schooling as a result of greater investment (Do and Phung, 2010). Moreover, if the characteristics of women who get pregnant and give birth during a boom versus a slump are different, the baseline results would be biased. In fact, studies like Buckles and Hungerman (2013) document that women who give birth in different seasons have different attributes. To investigate whether women who plan pregnancy during a boom versus a slump are different, following Akresh et al. (2012) and Dagnelie et al. (2018) we regress mother and household characteristics (education, age, height, number of children and husband's occupation) against a price shock in the year prior to the year of birth. Columns (4) to (8) of Table D.6 report these results. None of these characteristics of women investigated are related to in utero price shocks: fertility selection does not seem to be a major issue in our study.[9]

[7]We use the birth recode of GDHS.

[8]Gender imbalances in mortality might have been expected given the fact that boys are known to be more fragile in utero than girls (Kraemer, 2000; Eriksson et al., 2010). Many empirical studies indeed document that in utero shocks reduce male births (Almond and Mazumder, 2011; Valente, 2015; Dagnelie et al., 2018). However, these studies generally relate to large-scale shocks such as the outbreak of civil war or the occurrence of natural disasters (Beshir and Maystadt, 2020).

[9]We cannot exclude that our evidence with respect to the lack of selective mortality and fertility might be due to a lack of statistical power. To correct for any potential mortality

Table D.5: Estimated effect of current-year cocoa price shock on labour supply of mothers

	(1) Any work	(2) Agri. self employed or contributing to family	(3) Non-agri. self employed or contributing to family
Cocoa Price × Cocoa Producer Region	0.145**	0.171	0.048
	(0.067)	(0.086)	(0.093)
	[0.041]	[0.256]	[0.704]
Observations	34,582	34,582	34,582
Region of birth FE	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): gender, age, and gender of household head. Column (1) reports results on any work, and column (2) shows the effect of price shock on agricultural employment, and column (3) shows the effect of price shock on non-agricultural employment. Survey weights are used in the regression estimations.

Table D.6: Mortality and Fertility selection checks

	Mortality selection			Fertility selection				
	(1) Miscarriage	(2) Boy birth	(3) Neonatal death	(4) Mother years of education	(5) Mother age	(6) Mother height	(7) Number of births	(8) Husband in agriculture
In-utero Cocoa Price × Cocoa Producer Region	0.018	-0.007	0.003					
	(0.009)	(0.010)	(0.005)					
	[0.304]	[0.797]	[0.547]					
In-utero Cocoa Price × Cocoa Producer Region				0.046	-0.145	3.938	0.062	0.002
				(0.134)	(0.123)	(3.329)	(0.057)	(0.011)
				[0.769]	[0.283]	[0.311]	[0.343]	[0.875]
Observations	41,419	66,226	66,226	67,656	67,676	42,383	67,676	66,463
Birth region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth region trends	Yes	Yes	Yes					

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. For mortality analysis, we also controlled for maternal characteristics such as: education, age, urban, number of births, husband occupation, ethnicity and religion. Survey weights are used in the regression estimations.

and fertility selection, we therefore follow Shah and Steinberg (2017) and Dercon and Porter (2014) and re-run the baseline results above introducing household fixed effects to compare outcomes of siblings. Table D.7 reports these results. The baseline results are robust to sibling comparison.

Table D.7: Correction for selection, cognitive outcomes

	(1) Raven/IQ	(2) Grade
	Panel A: Effects of average early life price shocks	
Early-life Cocoa Price × Cocoa Producer Region	5.693	1.196***
	(7.055)	(0.153)
	[0.502]	[0.000]
Observations	2,228	42,711
	Panel B: Effects of in utero price shocks	
In-utero Cocoa Price × Cocoa Producer Region	10.514**	1.031***
	(4.826)	(0.099)
	[0.048]	[0.000]
Observations	2,228	42,711
Household FE	Yes	Yes
Region of birth FE	Yes	Yes
Year of birth FE	Yes	Yes
Region of birth trends	Yes	Yes
Child Controls	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child and gender of household head. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

Appendix D.4 Other robustness checks

Cocoa production intensity. The baseline results use an indicator of whether or not a region produces cocoa. A region is treated as cocoa producing if the fraction of land devoted to cocoa is greater than 0%. As a robustness analysis, we use cocoa production intensity (Figure B.3). The variable of interest is constructed as the interaction between the intensity variable and the price variables. We re-estimate both the contemporaneous and early-life regressions using this measure of shock. Tables D.8 and D.9 present the results. While the contemporaneous effects are consistently robust to this specification, the early-life effects are not.[10] We also test for the robustness of the results by dropping regions with a very low production of cocoa (Greater Accra and Volta). Tables D.10 and D.11 report these results. The estimates are largely similar to the baseline effects.

High prices vs low prices. In Table D.12 and Table D.13, we report results from regressions that split the real cocoa price into high-price events and low-price events. Specifically, using quartile ranking, we split the cocoa price series into three groups: high price, low price and a reference category.The high price category is an indicator that takes the value of 1 if the price is in the top quartile and 0 otherwise. The low price category is an indicator that takes the value of 1 if the price is in the bottom quartile and 0 otherwise. The reference group is an indicator that takes the value of 1 if the price is between these groups. Table D.12 shows the results of the contemporaneous analysis. In panels A and B, we can see that high prices lead to a reduction in current attendance and grade-for-age and that low prices boost attendance and grade-for-age.

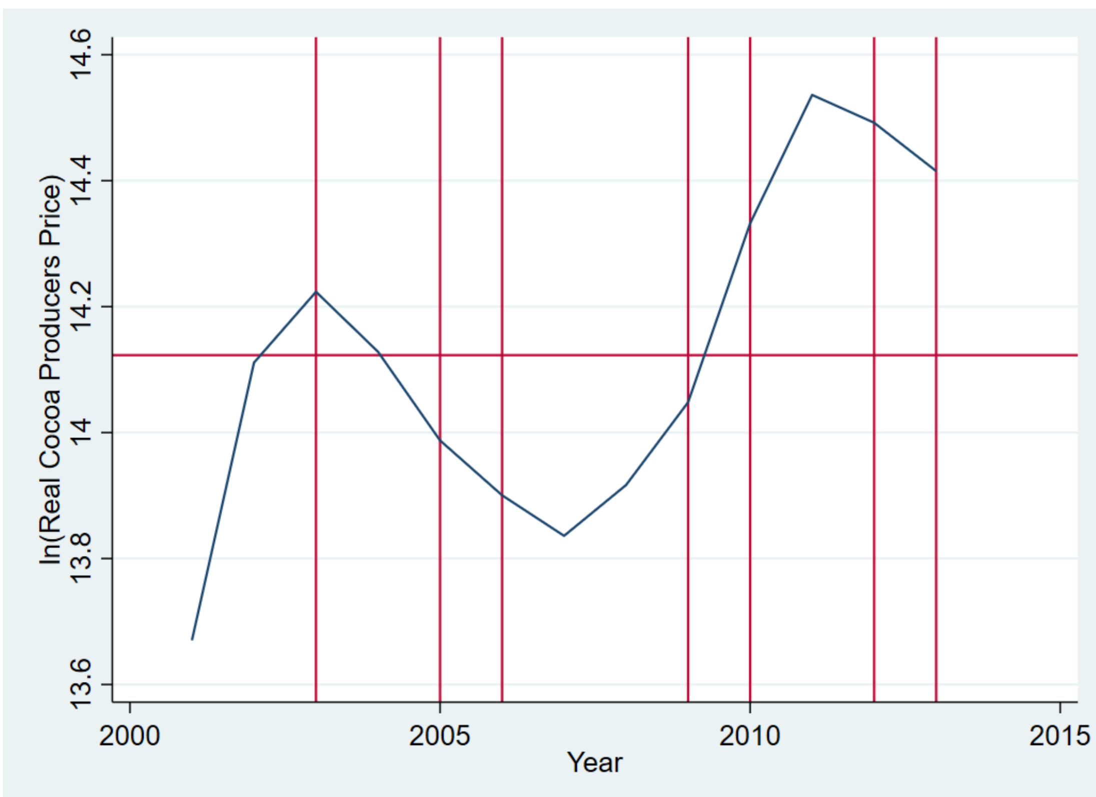
Table D.13 reports a similar analysis for the early-life effects of cocoa price shocks. While we find a significant negative effect of low prices, there is no evidence of high prices improving cognition. To understand these results further, in columns (2), (4), (6) and (8), we report regressions of outcomes on the interaction between being a cocoa-producing region and dummies that indicate whether prices belong to a specific quartile, with the first quartile being the reference group. The results show that the strongest positive effects are obtained from the third quartile, not at the highest extreme of the price distribution. Adhvaryu et al. (2019) also found similar results.

The risk of over-fitting. As previously mentioned, we observe a positive trend of the real producer price of cocoa after 2000. The existence of such a trend motivates our preferred results to be those from regressions with region-specific time trends. Nonetheless, in this

[10]This may be due to the fact that the intensity measure is constructed from a dataset based on a survey conducted as recently as 2012 and may not capture the intensity of cocoa production when children were in utero.

analysis, we also provide an additional robustness check. We restrict our analysis to the most recent years (years in the 21^{st} century), where we can find price variations that resemble booms and recessions. Figure D.1 depicts the time series of the real producer price of cocoa for most recent years (the 21^{st} century). It shows higher prices (booms) in 2003, 2010, 2012 and 2013. For this analysis, we use the GLSS surveys conducted in 2005/6 and 20012/13, in addition to surveys that were not used in the main analysis (the Ghana Education Impact Evaluation Survey (GEIES) from 2003 and the Ghana Socioeconomic Panel Survey from 2009/2010). Table D.14 reports the results. We find similar results to the baseline analysis, especially for the attendance outcome.

Figure D.1. Real Producer Price of Cocoa (Time Series) for recent years used in the Table D.14. The vertical lines represent the interview years. The horizontal line shows the average price over the sample.



Source: Authors' computation using data from Teal(2002) and Ghana Cocoa Board

Table D.8: Robustness check using intensity of cocoa production, contemporaneous

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Current attendance			
Cocoa Price × Cocoa Producer Intensity	-0.333	-0.484	-0.305	0.051
	(0.208)	(0.215)	(0.244)	(0.221)
	[0.186]	[0.104]	[0.418]	[0.831]
Observations	58,568	31,533	14,829	12,206
	Panel A: Grade-for-age			
Cocoa Price × Cocoa Producer Intensity	-0.198*	-0.276**	-0.129	-0.100
	(0.080)	(0.122)	(0.071)	(0.146)
	[0.052]	[0.045]	[0.166]	[0.573]
Observations	49,621	26,451	12,629	10,541
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Panel A reports results on current attendance, panel B shows the effect of price shock on grade-for-age, and panel C shows the effect of price shock on engaging in any work. Survey weights are used in the regression estimations.

Appendix D.5 Gender imbalances in the human capital effects of price shocks

Conceptually, when there is a cocoa price boom boys in cocoa-producing regions may work in the cocoa farms and in sectors connected to cocoa production. Girls may also engage in additional household chores (to substitute adults who have gone to the fields). It might be expected that both boys and girls work more and attend school less. However, the empirical evidence on the gender imbalances of income shocks on schooling/child labour is mixed. For instance, Kruger (2007) finds that in Brazil, both boys and girls are less likely to leave school and more likely to work when economic conditions improve. Similar results were found by Shah and Steinberg (2017) for India. However, Edmonds (2006) documents that boys are

Table D.9: Robustness check using intensity of cocoa production, early-life and in utero

	(1) Raven/IQ	(2) Grade
	Panel A: Effects of Average early-life price shocks	
Early-life Cocoa Price × Cocoa Producer Intensity	-3.108	0.790
	(9.856)	(1.017)
	[0.811]	[0.434]
Observations	2,826	49,621
	Panel B: Effects of in utero price shocks	
In-utero Cocoa Price × Cocoa Producer Intensity	-2.968	0.745
	(8.799)	(0.706)
	[0.745]	[0.312]
Observations	2,826	49,621
Region of birth FE	Yes	Yes
Year of birth FE	Yes	Yes
Survey year FE	Yes	Yes
Region of birth trends	Yes	Yes
Controls	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values.s *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of child and gender of household head. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

more impacted by income shocks in terms of schooling and labour supply than girls in South Africa. In this section, we estimate the effect of contemporaneous shocks separately for boys and girls. Table D.15 reports the results regarding contemporaneous effects estimated for boys and girls. Columns (1) to (4) report the results for boys and columns (5) to (8) present results for girls. In line with Kruger (2007) and Shah and Steinberg (2017), the estimates show that a current-year cocoa price boom has no differential effect on the attendance of boys and girls.

Biologically, boys are more vulnerable in utero than girls, as male foetuses are more fragile (Shettles, 1961; Mizuno, 2000; Kraemer, 2000; Catalano et al., 2006; Eriksson et al., 2010). As a result, a larger effect of an in utero price boom on the outcomes of boys is expected. To test whether this is the case, we estimate the effect of in utero price shocks on cognition and

Table D.10: Robustness check after dropping Accra and Volta from the sample production, contemporaneous

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Current attendance			
Cocoa Price × Cocoa Producer Region	-0.204**	-0.293**	-0.125	-0.045
	(0.075)	(0.075)	(0.079)	(0.108)
	[0.041]	[0.034]	[0.154]	[0.729]
Observations	47,259	25,610	11,908	9,741
	Panel B: Grade-for-age			
Cocoa Price × Cocoa Producer Region	-0.162**	-0.238***	-0.049	-0.094
	(0.030)	(0.042)	(0.029)	(0.067)
	[0.014]	[0.005]	[0.315]	[0.241]
Observations	40,425	21,649	10,263	8,513
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Panel A reports results on current attendance, panel B shows the effect of price shock on grade-for-age. Survey weights are used in the regression estimations.

grade attainment for boys and girls separately. Table D.16 shows these results. Columns (1) and (2) show the effect for boys and columns (3) and (4), for girls. The results indicate that the effects seem to be larger for boys.

Table D.11: Robustness check after dropping Accra and Volta from the sample, early-life and in utero

	(1) Raven/IQ	(2) Grade
	Panel A: Effects of Average early-life price shocks	
Early-life Cocoa Price × Cocoa Producer Region	11.117	1.308**
	(4.856)	(0.208)
	[0.140]	[0.031]
Observations	2,234	40,803
	Panel B: Effects of in utero price shocks	
In-utero Cocoa Price × Cocoa Producer Region	9.694*	1.042**
	(3.680)	(0.128)
	[0.054]	[0.015]
Observations	2,234	40,803
Region of birth FE	Yes	Yes
Year of birth FE	Yes	Yes
Survey year FE	Yes	Yes
Region of birth trends	Yes	Yes
Controls	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of child and gender of household head. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

Table D.12: High price vs low price, contemporaneous

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Current attendance			
High Price X Cocoa Producer Region	-0.112**	-0.132**	-0.083**	-0.097**
	(0.031)	(0.035)	(0.033)	(0.032)
	[0.011]	[0.022]	[0.038]	[0.024]
Low Price X Cocoa Producer Region	0.061	0.105**	0.007	-0.015
	(0.040)	(0.038)	(0.030)	(0.094)
	[0.255]	[0.036]	[0.819]	[0.865]
Observations	58,568	31,533	14,829	12,206
	Panel B: Grade-for-age			
High Price X Cocoa Producer Region	-0.022	-0.065**	0.026	0.032
	(0.015)	(0.021)	(0.016)	(0.024)
	[0.318]	[0.047]	[0.196]	[0.260]
Low Price X Cocoa Producer Region	0.064**	0.091**	0.013	0.037
	(0.023)	(0.040)	(0.020)	(0.031)
	[0.041]	[0.031]	[0.622]	[0.314]
Observations	49,621	26,451	12,629	10,541
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Panel A reports results on current attendance, panel B shows the effect of price shock on grade-for-age, and panel C shows the effect of price shock on engaging in any work. High price category is an indicator that takes 1 if price is above and equal to Price Xtile 8 and 0 otherwise. Low price category is an indicator that takes 1 if price is below and equal to Price Xtile 3 and 0 otherwise. Survey weights are used in the regression estimations.

Table D.13: High price vs low price, early-life and in utero

	(1) Raven	(2) Raven	(3) Grade	(4) Grade
	Panel A: Effects of average early life price shocks			
Early High Price X Cocoa Producer Region	1.923		-0.193	
	(2.637)		(0.088)	
	[0.489]		[0.149]	
Early Low Price X Cocoa Producer Region	-6.214		-1.486**	
	(2.514)		(0.197)	
	[0.204]		[0.018]	
Early Price quartile 2 X Cocoa Producer Region		3.072		1.628***
		(2.722)		(0.175)
		[0.380]		[0.008]
Early Price quartile 3 X Cocoa Producer Region		7.749*		1.331**
		(2.542)		(0.221)
		[0.054]		[0.019]
Early Price quartile 4 X Cocoa Producer Region		7.333**		1.273**
		(2.871)		(0.186)
		[0.047]		[0.017]
Observations	2,826	2,826	49,621	49,621
	Panel A: Effects of in-utero price shocks			
In utero High Price X Cocoa Producer Region	0.760		-0.290*	
	(2.283)		(0.107)	
	[0.725]		[0.077]	
In utero Low Price X Cocoa Producer Region	-6.718		-1.542**	
	(2.602)		(0.122)	
	[0.135]		[0.011]	
In Utero Price quartile 2 X Cocoa Producer Region		5.281		1.551***
		(3.555)		(0.125)
		[0.294]		[0.000]
In Utero Price quartile 3 X Cocoa Producer Region		7.768*		1.530**
		(2.428)		(0.128)
		[0.071]		[0.015]
In Utero Price quartile 4 X Cocoa Producer Region		7.443*		1.252***
		(3.036)		(0.108)
		[0.073]		[0.009]
Observations	2,826	2,826	49,621	49,621
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of child and gender of household head. High Price is a dummy equal to 1 if Price Xtile is above or equal to 8 and 0 otherwise; Low Price is a dummy equal to 1 if Price Xtile below or equal to Price Xtile 3 and 0 otherwise. In columns (3 and 6), Price Xtile 1 X CocoaProducer is the omitted (and thus the reference) group. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

Table D.14: Restricting sample to recent years, contemporaneous

	All (age 6-17)	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)
	Panel A: Current attendance			
Boom X Cocoa Producer Region	-0.130**	-0.133**	-0.112*	-0.147**
	(0.041)	(0.036)	(0.053)	(0.054)
	[0.012]	[0.048]	[0.051]	[0.024]
Observations	40,775	21,386	10,491	8,898
	Panel B: Grade-for-age			
Boom X Cocoa Producer Region	0.003	-0.011	0.024	0.011
	(0.018)	(0.025)	(0.017)	(0.020)
	[0.885]	[0.769]	[0.290]	[0.598]
Observations	41,053	21,480	10,587	8,986
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of the child, child age, and gender of household head. Panel A reports results on current attendance, panel B shows the effect of price shock on grade-for-age. Survey weights are used in the regression estimations.

Table D.15: Heterogeneous effect of contemporaneous price shocks by gender

	Boys				Girls			
	All	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)	All	Primary (age 6-11)	Junior High (age 12-14)	Senior High (age 15-17)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Current Attendance							
Cocoa Price × Cocoa Producer Region	-0.212**	-0.287**	-0.153*	-0.090	-0.234*	-0.310**	-0.113	-0.131
	(0.077)	(0.085)	(0.074)	(0.104)	(0.078)	(0.074)	(0.081)	(0.132)
	[0.020]	[0.017]	[0.052]	[0.452]	[0.052]	[0.040]	[0.221]	[0.402]
Observations	30,141	16,133	7,669	6,339	28,427	15,400	7,160	5,867
	Panel B: Grade-for-age							
Cocoa Price × Cocoa Producer Region	-0.143**	-0.230**	-0.054	-0.011	-0.140**	-0.213**	0.022	-0.101
	(0.054)	(0.090)	(0.049)	(0.074)	(0.025)	(0.041)	(0.049)	(0.069)
	[0.040]	[0.019]	[0.493]	[0.907]	[0.018]	[0.027]	[0.693]	[0.174]
Observations	25,575	13,535	6,593	5,447	24,046	12,916	6,036	5,094
Region of birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region time trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of interview level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Child age, and gender of household head. Panel A reports results on current attendance, and panel B shows the effect of price shock on grade-for-age. Columns 1 to 4 reports on effects on boys, while columns 5 to 8 reports on results on girls. Survey weights are used in the regression estimations.

Table D.16: Heterogeneous effect of in utero shock on cognition by gender

	Boys		Girls	
	(1) Raven/IQ	(2) Grade	(3) Raven/IQ	(4) Grade
	Panel A: Effects of average early life price shocks			
Early-life Cocoa Price × Cocoa Producer Region	18.752	1.525**	6.298	1.244**
	(7.209)	(0.206)	(4.079)	(0.251)
	[0.182]	[0.011]	[0.177]	[0.035]
Observations	1,454	25,575	1,372	24,046
	Panel B: Effects of in utero life price shocks			
In-utero Cocoa Price × Cocoa Producer Region	15.298**	1.266***	7.255*	0.912***
	(5.022)	(0.067)	(3.304)	(0.202)
	[0.029]	[0.006]	[0.065]	[0.036]
Observations	1,454	25,575	1,372	24,046
Region of birth FE	Yes	Yes	Yes	Yes
Year of birth FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Region of birth trends	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Robust standard errors (clustered at the region of birth level) in parentheses. The asterisks next to the coefficients are based on the wild bootstrap p-values. *** p<0.01, ** p<0.05, * p<0.1. Controls include (X): Gender of household head. Columns 1 to 2 reports on effects on boys, while columns 3 to 5 reports on results on girls. The source of data for Raven/IQ outcome is self-weighting samples. However, survey weights are used in the regression estimation of grade outcome.

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