

Do Parental Income Shocks Boost the Realization of Children’s Genetic Potential? Evidence from the UK Child Tax Credit Expansion.

Alicia García-Sierra¹ and Inés Echevarría García²

¹Swiss Centre of Expertise in Life Course Research LIVES, University of Lausanne

²Nuffield College, University of Oxford

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Short abstract

A central challenge in the study of social inequalities is to understand how genetic factors and social environments interact to shape life outcomes. Existing research often treats socioeconomic status (SES) as a broad category, making it difficult to identify which specific SES component moderates the relationship between genetic endowments and life chances. This study isolates the role of parental income by exploiting the quasi-natural experiment created by the 2003 Child Tax Credit (CTC) reform in the United Kingdom, which altered family income exogenously based on pre-reform earnings and family composition. Using data from the Millennium Cohort Study, we estimate instrumental-variables difference-in-differences (IV–DiD) models to assess how policy-induced income changes affect the relationship between children’s polygenic indices for educational attainment and cognitive and developmental outcomes. The results indicate that exogenous increases in parental income modestly improve children’s cognitive outcomes at age five. However, the effects do not significantly vary by children’s genetic propensities, suggesting that additional income benefits children across the genetic distribution rather than amplifying existing inequalities. These findings contribute to research on gene–environment interactions and social inequality by demonstrating that policy-induced income gains can enhance early cognitive outcomes but do not appear to widen genetic disparities.

Long abstract

Motivation

A central challenge in the study of social inequalities is to understand how genetic factors and social environments interact to shape life outcomes. The literature on gene–environment interactions has identified two main scenarios. The first suggests that the association between genetic predispositions and life outcomes is stronger in higher socioeconomic status environments (Rowe et al., 1999; Scarr-Salapatek, 1971). High-SES families are more likely to provide conditions that allow children’s genetic potential to flourish, resulting in stronger links between genetic traits and outcomes such as education, income, or occupation. An alternative view, drawn from the compensatory advantage literature (Bernardi, 2014; Conley & Glauber, 2008), argues that high-SES families compensate for their children’s lower genetic predispositions. As a result, the association between genes and outcomes becomes weaker because advantages in the social environment buffer genetic disadvantages.

Although much has been written about the role of family socioeconomic status in moderating the relationship between genes and life chances, existing literature often refers broadly to 'parental SES', 'socioeconomic background', or 'class of origin', without specifying *which aspects of parents' SES moderate the strength of the link between children's genetic traits and life outcomes*. The problem with these umbrella terms is that they obscure the underlying mechanisms and limit the potential for targeted policy interventions. Without identifying which specific SES factor moderates the expression of genetic potential, it is impossible to design effective policies for reducing inequalities in genetic realisation.

Moreover, empirically, scholars have often sought to capture this broad notion of socioeconomic background through measures such as parental education (Bernardi & Ghirardi, 2025; Grant et al., 2010), school characteristics (Hart et al., 2013; Stienstra et al., 2024), or composite indices combining multiple SES dimensions (Rhemtulla & Tucker-Drob, 2012). However, these approaches face an important limitation: socioeconomic indicators are highly correlated (Cheesman et al., 2022). Parents with higher education often also have higher incomes, better jobs, and live in wealthier neighbourhoods with better schools. This interdependence makes it difficult to disentangle the influence of each SES component.

To overcome this challenge, our study isolates the moderating role of parental income in the relationship between children's polygenic indices (PGIs) and their life outcomes. We exploit a quasi-natural experiment: the Child Tax Credit introduced in April 2003 in the UK.

Contributions

This study makes two main contributions. First, it develops a theoretical framework to disentangle the distinct roles of socioeconomic status components in gene–environment moderation studies. As argued above, understanding which specific aspects of parental SES shape the relationship between genetic endowments and life chances is essential to clarify the mechanisms of social inequality.

Second, it highlights the importance of parental income—a dimension that has received comparatively less attention than parental education or occupational class in the gene–environment literature. We argue that parental income warrants special consideration for several reasons. First, higher parental income provides children with direct material resources—such as educational materials, nutritious food, and quality healthcare (Yeung et al., 2002)—that create environments more conducive to the realisation of genetic potential. Second, greater income reduces financial stress and improves parents' mental health, leading to more stable and supportive family environments (Masarik & Conger, 2017). Third, income can shape parenting behaviours that are critical for children's cognitive and socio-emotional development (Kalil, 2015), thereby amplifying the expression of genetic predispositions. Finally, higher income facilitates access to enriched institutional contexts—such as better schools or extracurricular opportunities—that further foster the translation of genetic potential into achievement. Together, these mechanisms suggest that parental income may play a distinctive and multifaceted role in moderating the link between children's genetic propensities and their life outcomes.

Analytical Design

This study exploits the Child Tax Credit (CTC) introduced in the United Kingdom in 2003 as part of the Tax Credits Act 2002. The CTC was a means-tested benefit based on family income in the preceding tax year (for the first application round, 2001 income). Crucially, eligibility did not depend on parental employment status; it required only that the child lived in the UK and was under the age of 16. The benefit was paid to the main carer in the household (Brewer, 2003). The reform aimed to simplify and expand financial support for families with children, thereby improving children's life chances.

The amount received depended on gross family income and the number of children in the household. **Figure 1** illustrates the schedule for a family with one child. Families with annual incomes below £13,230 were eligible for the full benefit (approximately £2,000). Beyond this threshold, the benefit tapered at a rate of 37 pence per additional pound of income until £17,135. For families earning above £50,000, a second taper applied, reducing the benefit at 6.7 pence per pound until it phased out entirely at £58,134.

Method

To strengthen the causal interpretation of the results, we extend the main difference-in-differences framework by implementing an instrumental-variable difference-in-differences (IV–DiD) design. The main challenge is that income is not randomly distributed: families with different income levels may differ in many observed and unobserved characteristics—

such as parental education, occupation, or health—that are also correlated with children’s development and with the way their genetic potential is expressed.

To address this endogeneity, we exploit the quasi-experimental variation generated by the 2003 Child Tax Credit reform. Specifically, we first compute the predicted CTC entitlement for each household based on their pre-reform income and family composition. This predicted benefit captures the intensity of exposure to the reform—families with lower baseline income were entitled to higher benefits under the new system. We then interact this predicted entitlement with an indicator for the post-reform period, using this interaction as an instrument for actual household income.

This approach allows us to isolate the component of income that is exogenously shifted by the reform, separating it from income changes driven by family behavior or other confounding factors. In the first stage, we verify that this interaction significantly predicts income changes, confirming instrument relevance. In the second stage, we estimate the effect of the instrumented (policy-induced) income change on children’s cognitive development and on the interaction between income and children’s polygenic indices.

The model includes individual fixed effects, which absorb all time-invariant family and child characteristics, and year fixed effects, which account for common macroeconomic shocks and period-wide influences. Identification therefore relies on within-family income variation caused by the reform’s intensity of exposure, under the assumptions of parallel trends and a valid exclusion restriction—that the CTC reform affects children’s outcomes only through its impact on family income.

Data

The data we employ comes from the Millenium Cohort Study (MCS), which is a longitudinal cohort-based survey following children born in 2000/2001. It is appropriate for our study because it follows these children across 23 years (8 waves in total), and therefore, includes observations both before and after the CTC policy was implemented. We focus on waves 1, 2, and 3, which correspond to ages 9 months, 3 years old, and 5 years old.

Variables

The *outcome* of this study is child cognitive ability and developmental level. We operationalize cognitive ability using the British Ability Scales II (BAS II), in all its subscales (the BAS II Naming Vocabulary, Pattern Construction, and Picture Similarities measures. For developmental outcomes we use the items corresponding to child self-regulation and the



Figure 1. Child Tax Credit benefits by levels of annual gross family income.

strengths and difficulties questionnaire (SDQ). Our main *predictors* are children’s genetic traits, operationalized through the polygenic index for educational attainment (PGI EA), which combines the impact of multiple genetic variants in a given outcome (i.e., educational attainment in this case). We used annual family gross income in the year 2001 to obtain the predicted CTC based on the policy rules outlined above.

Preliminary Results

Table 1. Results for the cognitive outcome BAS Naming Vocabulary Standardized from a 2SLS model (IV-DiD)

	First stage (DV: Income)	IV–DiD main (DV: BAS Naming Vocabulary)	IV–DiD G×E (DV: BAS Naming Vocabulary)
Predicted CTC*Post Reform	-4.53* (1.93)		
Income (instrumented with Predicted CTC x Post Reform)		0.007* (0.003)	-0.012 (0.242)
Post x PGI			-3.17 (44.2)
Income x PGI			0.031 (0.430)
Individual FE	Yes	Yes	Yes
Age FE	Yes	Yes	Yes
Observations	8,778	8,778	8,778

Note: cluster-robust standard errors in parentheses. * $p < .05$. All models include individual and year fixed effects. The first-stage F-statistic (Model 2) 10.639, $p = 0.001$, suggesting moderately strong instrument relevance.

The first-stage regression confirms that the interaction between predicted CTC and the post-reform period significantly predicts changes in household income ($\beta = -4.53$, $SE = 1.93$, $p < .05$ in **Table 1**). The negative sign is expected: families with higher predicted CTC exposure (typically those with lower pre-reform income) saw larger income gains, consistent with the intended redistributive effect of the reform. This validates the use of the interaction term as a relevant source of exogenous income variation.

In the second stage, the instrumented estimate of income shows a small but statistically significant positive effect on children’s cognitive development ($\beta = 0.007$, $SE = 0.003$, $p < .05$). This result suggests that policy-induced increases in family income modestly improve children’s cognitive outcomes, after accounting for all time-invariant family characteristics and common period shocks through individual and year fixed effects. The effect size is small but meaningful, given that the variation in income comes from an external policy rather than behavioral or endogenous income changes.

The model allowing for gene-by-environment moderation does not provide evidence of differential effects by genetic propensity for education. Both the post \times PGI interaction ($\beta = -3.17$, $SE = 44.2$) and the income \times PGI interaction ($\beta = 0.031$, $SE = 0.430$) are statistically insignificant and close to zero. This indicates that the relationship between genes and cognitive outcomes does not vary with an exogeneous increase in family income.

Overall, the results imply that while the CTC reform–induced income gains had a small but positive causal impact on children’s cognitive outcomes, these benefits were broadly similar across the genetic distribution—suggesting no clear evidence of genetic moderation in how families translate income into developmental advantages.

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