Fertility, Household Consumption, and Carbon Footprint

Niaoniao You

Disclosure: This research has not received any funding support. I have no relevant or material financial relationships that bear on this research.

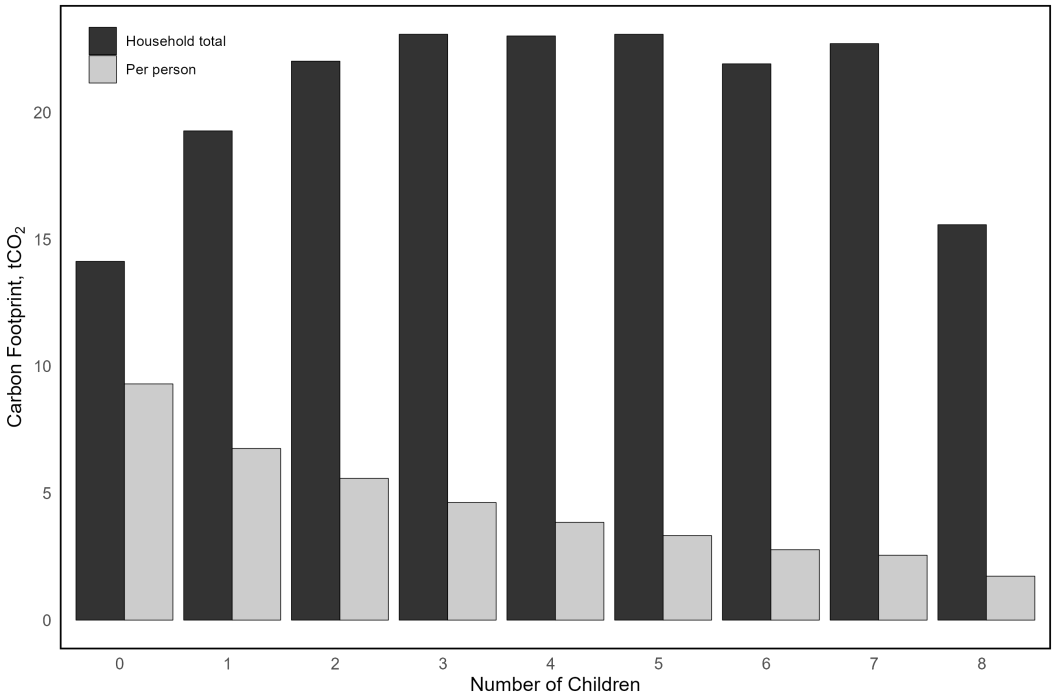
1 Introduction

Human activities, compounded with population growth, leave a large carbon footprint that has accumulated over time and caused climate change (AAAS 2009). Population growth rates and fertility rates are trending lower in high-income countries. In a survey on childless U.S. adults (Pew Research Center 2024), 26% of adults below 50 cite concerns about the environment, including climate change, as a major reason for unlikely having children. However, potential parents will spend their income on something regardless, and the eventual environmental impact depends on whether having fewer children changes consumption patterns towards more or less greenhouse gas (GHG) emissions. Slower population growth may not slow GHG accumulation as much as expected, after accounting for consumption pattern changes related to a smaller household size.

To assess this question, I combine data on household expenditure with measures of carbon footprint by expenditure category. The spending data, with household demographics, are drawn from the Consumer Expenditure Survey (CEX) from the U.S. Bureau of Labor Statistics (BLS). I document three empirical facts related to fertility and household consumption-based carbon footprint: (1) the household carbon footprint increases with the number of children in the household, (2) there is diminishing marginal increase of carbon footprint in the number of children in a household, and (3) household carbon footprint increases by about one-tenth of the average carbon footprint per person in the U.S. with one more child in a household. The first two facts can be seen in Figure 1 below and the third fact will be shown in Section 4. These patterns suggest that larger households do consume more food and energy, but they travel less.

To estimate the causal effect of having one more child on household carbon footprint, I apply two standard instruments for exogenous variation in the number of children, newly in this context. The first instrument is the first two children being the same sex (Angrist and Evans 1998) and the second is multiple birth (twinning) (Behrman, Rosenzweig, and Taubman 1994). I find that among households with at least two children, having one more child increases the total household carbon footprint by around one-tenth of the U.S. per-person carbon footprint. Back-of-envelope calculations based on the causal estimates suggest that a child's carbon legacy is likely much less than the existing environmental science literature claims. Finally, I (plan to) use a model of fertility, consumption, and growth to

Figure 1: Number of Children and Consumption-Based Carbon Footprint



Notes: This bar chart compares the annual average household total carbon footprint (dark shade) and average carbon footprint per person in each household (light shade), by number of children in a household. The vertical axis shows the annual consumption-based CO_2 emissions in metric tons, calculated as described in Section 2.

understand what a lower fertility rate and related changes in consumption patterns imply for carbon footprint and economic growth in the long run.

Research on the interaction between fertility and climate change is nascent. Enriching the existing works that use aggregate data with a quantitative model to understand the economic consequence of lower fertility in the era of climate change (Gerlagh, Lupi, and Galeotti 2023, Henderson et al. 2024w), this paper focuses on the consumption channel that has broad implications on demography-related climate change forecasts. This paper is one of a handful to consider how fertility affects carbon footprint and climate change mitigation (Gerlagh, Lupi, and Galeotti 2023), contrasting with the earlier works that examine the effect of climate change on fertility (Casey et al. 2019).

This finding relates to a large literature on the rebound effect, which says that energy efficiency improvement is often followed by higher energy usage that offsets the initial energy-saving expectations (Gillingham, Rapson, and Wagner 2016). This paper shows that GHG emission reductions related to a lower fertility rate (and a slower population growth) are likely smaller than suggested by the existing literature due to a similar rebound effect related to changes in household consumption patterns.

2 Data

The consumption-based household carbon footprint is calculated from expenditures in CEX, price levels, and emission factors. The baseline household-level carbon footprint is measured as CO_2 emissions from direct energy usage, food, and transportation expenditures in the CEX Interview Surveys. All nominal expenditures are adjusted to the 2022 price level to calculate consumption units that are then multiplied by emission factors to calculate the carbon footprint. Emission factors matched to the expenditure categories for 2022 are from the U.S. Energy Information Administration (EIA), the U.S. Department of Agriculture (USDA), and the Bureau of Transportation Statistics (BTS).

Table 1: Summary statistics of household carbon footprint in the CEX sample

	Household CO_2, Per Person	Components, % of Household Total			
	% of U.S. Per Person Average	Energy	Food	Air Trsp.	Oth. Pub. Trsp.
Min.	0.0	0.0	0.0	0.0	0.0
25th pctl.	25.9	76.2	10.4	0.0	0.0
Mean	46.9	79.4	19.1	0.9	0.6
Median	39.9	84.1	15.1	0.0	0.0
75th pctl.	59.9	89.2	21.9	0.0	0.0
Max.	1440.3	100.0	100.0	86.4	100.0
SD	32.3	17.5	16.0	3.9	3.0

Notes: The sample consists of interview survey units in the Consumer Expenditure Survey (CEX) public-use microdata (PUMD) from 2004 to 2022. The observation is at the household-annual level. Each column shows the minimum, 25^{th} percentile, mean, median, 75^{th} percentile, maximum, standard deviation, and number of observations of the variable in the column header. The left panel shows summary statistics of the calculated consumption-based CO_2 per person in each household, expressed as a percentage of the annual U.S. CO_2 emission per person in the respective year. The annual U.S. CO_2 emission per person ranges from 13.5 to 22.7 metric tons.

Table 1 shows summary statistics of the consumption-based carbon footprint. As shown in the left panel, compared with the annual CO_2 emission per person in the U.S. according to EDGAR, my carbon footprint calculation is on average smaller. Still, my calculations consistently cover about half of total CO_2 emissions per person in the U.S. The underestimation is due partly to omitted emissions related to expenditures on services and many manufactured goods. The emission factors used in calculation also contribute to the underestimation due to progress on decarbonization, especially in the energy and transportation industries.

3 Empirical Strategy

The decision to have children and the number of children parents have are often decided jointly with consumption patterns and the associated household carbon footprint, making it challenging to causally estimate the impact of a child on consumption-based household

carbon footprint. Therefore, I use the sex mix of the first two children in a household, which is quasi-random, as an instrument for a household to have more than two children. This standard instrument in the literature is based on parents' preference to have both female and male children if they have more than one child. Besides the sex mix instrument, I also use twinning at birth as an instrument for exogenous variation in the number of children in a household. The baseline result is estimated using two-stage least squares (2SLS) with the following regression specification.

$$Y_i = \alpha + \beta X_i + W_i'\gamma + \epsilon_i \tag{1}$$

$$X_i = \psi + \pi Z_i + W_i'\delta + \eta_i \tag{2}$$

X_i denotes the number of children in household i. Z_i denotes the instrumental variable for household i, either the sex mix of the first two children or twinning. W_i' denotes a vector of covariates for household i, including the log of before-tax household income in 2022 dollars, age of the reference person and its square value, race of the reference person, the interaction of education level and marital status indicators, the BLS urban designation, region, and state. β captures the local average treatment effect (LATE) of having more than two children on the outcome variable Y_i such as household expenditures on carbon-intensive categories and household carbon footprint on carbon-intensive expenditures.

$$Y_i = \alpha + \beta \hat{X}_i + \rho_1 S_{1i} + \rho_2 S_{2i} + W_i'\gamma + \epsilon_i \tag{3}$$

$$X_i = \psi + \pi SameSex_i + \rho_1 S_{1i} + \rho_2 S_{2i} + W_i'\delta + \eta_i \tag{4}$$

When using the $SameSex$ instrument, I control additionally for the sex of the first child, S_1, and the sex of the second child, S_2, as shown in equations above[1]. All other variables are the same as in the baseline specification.

4 Results

The main empirical result is that having one more child increases household carbon footprint by roughly one-tenth of the average carbon footprint per person. This estimated local average treatment effect is stable across different samples and instrumental variables. Table 2 presents the main estimation results of the effect of a child on household consumption-based carbon footprint. Columns (1) to (4) are estimated using equation (1) and columns (5) and (6) are estimated using equation (3). Columns (1) and (2) show regression results using the sample of households with at least one child. Columns (3) and (4) show regression results using the sample of households with at least two children. Columns (5) and (6) show regression results using the sample of households with two or three children. The positively significant coefficients on income and age in all regression specifications are consistent with existing evidence on the heterogeneity of carbon footprint along those dimensions.

[1]The $SameSex$ instrument can be slightly correlated with the sex of each child since the probability of the having a male child is slightly larger than 0.5 in the population.

Regression results show that, among households with at least two children, having one more child increases the total household carbon footprint by around one-tenth of the U.S. per-person carbon footprint. As my calculations of consumption-based carbon footprint only cover about half of the U.S. per-person carbon footprint, the estimate translates to an effect size of about one-fifth per-person carbon footprint increase caused by an additional child. The estimate is robust to both instrumental variables and the exclusion of households with more than three children.

Table 2: Carbon footprint effect of one more child

	At least one child		At least two children		Two or three children	
	(1)	(2)	(3)	(4)	(5)	(6)
Number of children	0.092***	0.101***	0.079***	0.136**	0.110***	0.093
	(0.002)	(0.007)	(0.003)	(0.065)	(0.005)	(0.077)
log(Income)	0.231***	0.231***	0.246***	0.247***	0.246***	0.246***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Age	0.021***	0.020***	0.023***	0.019***	0.022***	0.023***
	(0.001)	(0.001)	(0.002)	(0.004)	(0.002)	(0.003)
Age^2	-0.000***	-0.000***	-0.000***	-0.000	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Estimation	OLS	2SLS, Twin	OLS	2SLS, Same sex	OLS	2SLS, Same sex
Cluster	—	Region	—	Region	—	Region
Y mean	1.244	1.244	1.311	1.311	1.305	1.305
F-stat	—	8268.0	—	140.4	—	287.4
Sample size	130,439	130,439	80,072	80,072	71,711	71,711

Notes: The unit of observation is a consumer unit (household) in the Consumer Expenditure Survey (CEX). The sample consists of households with at least two children and less than ten children in the public-use microdata (PUMD) interview surveys from 2004 to 2022. Columns (1) to (4) are estimated using equation (1) and columns (5) and (6) are estimated using equation (3). *p<0.1; **p<0.05; ***p<0.01.

To compare the social costs of the carbon legacy of households with different numbers of children, I simulate the cumulative carbon footprint for three generations of households using regression estimates. Simulations suggest that one child adds roughly 2.6 adult's carbon legacy to the dynastic household head, compared to an estimate in the existing literature of as high as 5.7 times the lifetime carbon emission of a parent (Murtaugh and Schlax 2009). Using the same calibration with a static social cost of carbon, one child adds roughly one adult's social cost of carbon legacy to the dynastic household head.

5 Conclusion

This paper provides one of the first plausibly causal estimates of the impact of having a child on GHG emissions. The GHG emissions associated with one additional child are much smaller than an average adult because of consumption pattern responses to changes in household composition. This result highlights the importance of accounting for life-cycle household consumption patterns when calculating the carbon emission implications of a lower fertility rate and thus lower population growth.

Reference

AAAS (American Association for the Advancement of Science). 2009. "AAAS Reaffirms Statements on Climate Change and Integrity." *AAAS News*. https://www.aaas.org/news/aaas-reaffirms-statements-climate-change-and-integrity.

Angrist, Joshua D., and William N. Evans. 1998. "Children and Their Parents' Labor Supply: Evidence from Exogenous Variation in Family Size." *The American Economic Review* 88 (3): 450–77.

Behrman, Jere R., Mark R. Rosenzweig, and Paul Taubman. 1994. "Endowments and the Allocation of Schooling in the Family and in the Marriage Market: The Twins Experiment." *Journal of Political Economy* 102 (6): 1131–74.

Casey, Gregory, Soheil Shayegh, Juan Moreno-Cruz, Martin Bunzl, Oded Galor, and Ken Caldeira. 2019. "The Impact of Climate Change on Fertility." *Environmental Research Letters* 14 (5).

Gerlagh, Reyer, Veronica Lupi, and Marzio Galeotti. 2023. "Fertility and Climate Change." *The Scandinavian Journal of Economics* 125 (1).

Gillingham, Kenneth, David Rapson, and Gernot Wagner. 2016. "The Rebound Effect and Energy Efficiency Policy." *Review of Environmental Economics and Policy* 10 (1): 68-88.

Henderson, J. Vernon, Bo Yeon Jang, Adam Storeygard, and David N. Weil. 2024. "Climate Change, Population Growth, and Population Pressure." *NBER Working Paper* 32145.

Murtaugh, Paul A., and Michael G. Schlax. 2009. "Reproduction and the Carbon Legacies of Individuals." *Global Environmental Change* 19 (1): 14–20.

Pew Research Center. 2024. "The Experiences of U.S. Adults Who Don't Have Children."