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Do parents leave a smaller carbon footprint?

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Abstract

Do parents leave a smaller carbon footprint? While becoming a parent is transformational as one focuses more on the future, the time constraints are more binding right now. Using a unique data set that allows us to compare CO_2 emissions from Swedish two-adult households with and without children, we find becoming a Swedish parent causes a person to leave a larger carbon footprint—due to changes in transportation patterns and food consumption choices.

Key words: Children, parent, CO_2 emissions, sustainable consumption, time constraints, food, transportation

JEL code: D10, D90, Q54

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1. Introduction

Do parents leave a smaller carbon footprint? The answer is *a priori* ambiguous. Two countervailing forces are at work. First, becoming a parent is transformational—we focus more on the future, which suggests we might try to buy less carbon-intensive goods and services to reduce future risks of climate change (see e.g., Dresner et al., 2007; Paul, 2015; Teal and Loomis, 2000; Verplanken, 2010).[1] But the flip side is that now time constraints become more binding—parents drive kids to school and activities, and may eat more carbon-intensive meals to save time. What motive—transformational or time constraint—has the larger impact on parents' carbon footprint is an open question.

Herein we examine this question empirically by creating and examining a unique data set that allows us to compare CO_2 emissions from Swedish two-adult households with and without children.[2] Using this detailed data on household expenditures and CO_2 emissions (transportation, food, and heating/electricity for 2008-09), this paper provides the first rigorous test of whether parents themselves become more "green", e.g., have a smaller footprint. We find that two-adults in households with children increase CO_2 emissions relative to households without children. On net, becoming a Swedish parent causes a person to leave a larger carbon footprint—parenthood seems to cause the average person's CO_2 emissions to increase given changes in transportation patterns and food consumption choices. Swedish parents use carbon-based consumption as a

[1] A parent's environmental behavior may also be motivated by other factors, such as health or financial constraints (De Young, 2000; Whitmarsh, 2009). Families with children are systematically found to be worse off financially than their childless counterparts, and lower income typically contributes to lower CO2 emissions (see e.g., Richmond and Kaufmann, 2006). Financial scarcity itself may also change preferences (i.e., be transformative), via shifts in attention (Mani et al., 2013).

[2] Adults not living with children can still be parents to children who never shared or are not currently sharing their household. The most precise statement is that we compare adults who live with children to adults who do not live with children.

substitute for their tighter time constraints.[3] Since parents now confront tighter time constraints, he or she can buy back time by using more carbon-intense products, e.g., driving more, consuming more ready-to-go processed products. Altruistic parents' consumption may also be impacted by the child's immediate preferences for carbon-intense consumption, such as a taste for meat, flights to family friendly resorts, and so on.[4] Our results suggest the greenest Swede is childless and lives alone.[5]

Our results are striking given Sweden is our focus. If parenthood makes one greener, we would expect to see this behavior in Sweden relative to other developed countries. Most Swedes believe climate change is real and they have accepted sizable CO_2 taxes—both suggest that reducing one's carbon footprint for their off-springs matters. In addition, households with children are subsidized, which helps to alleviate some of the time crunch for parents. Sweden has generous parental leave, subsidized daycare, and parents have a legal right to reduced work hours (see e.g., Anxo, 2009; Ray et al., 2010). But Sweden also has one of the world's highest female labor participation rates (69.5% in 2015, as compared 51.4% in the European Union and 56.7% in the US)[6], which may add to the time constraint of household with children.

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[3] In a comprehensive report on time usage by Swedish households, Statistics Sweden (2012) shows that out of all people, parents with small children have the least leisure time (defined as time not spent working, paid or in the household). Mothers and fathers of children 7 years and younger have around four hours of daily leisure time, while a childless woman age 20-44 has around five hours of daily leisure time and a childless man of the same age has about six hours daily leisure time.

[4] Evidence suggests the influence of children on household consumption is strongest for goods and services used by children (e.g., holidays, food, entertainment, clothing), see e.g. (Gunter and Furnham, 1998; Howard and Madrigal, 1990; Wilson and Wood, 2004). Children may of course also be concerned about the environment, which in turn may affect household consumption. Even though children in the Nordic countries have been found to be more environmentally concerned than their parents (Autio and Heinonen, 2004; Carle, 2000), there is a substantial gap between their attitudes and actions (Ojala, 2007; SOU, 2004:104: 85–9).

[5] Our sample of one-adult households with children is limited – it consists of 219 households only. Although these households are interesting, and still included in our data, a comparison between two-adult households with and without children, for which we have more observations than for the single-adult households, seems more reliable.

[6] http://data.worldbank.org.

2. Data and Behavioral Model

We summarize our unique data in three steps. Appendix A provides the specific details. First, we estimated household quantities consumed of goods and services from a set of 4000 households surveyed by Statistics Sweden for 2008-2009. We limit our sample in two key ways: (i) we focus on households consisting of two adults (only), who have a positive household disposable income; and (ii) we exclude households in which at least one household member is retired. Our final sample had 2,692 Swedish households. Household characteristics include number of adults, number of children, age of household members, disposable income level, type of housing (apartment, house, ranch), and size of housing (in square meters). Tables 1 and 2 summarize the descriptive statistics on household characteristics, for all households in our sample and sub-groups of households.

Second, we then matched detailed consumption data on goods and services that constitute the vast majority of household CO_2 emissions with the corresponding CO_2 emissions. Classified according to the international COICOP classification system on a four-digit level, we capture detailed data on four expenditure groups: (a) food and non-alcoholic beverages, (b) transportation, (c) clothing, including shoes, and (d) housing. Tables 3 and 4 summarizes the expenditure groups and associated levels of CO_2 emissions. Third, we calculated quantities consumed by dividing expenditures by 2009 prices for all expenditure items.[7] We then matched each item with their CO_2 emissions per unit (Appendix A provides the specific matching figures and sources). For some expenditure groups, we used various sources for price and CO_2 emissions data, which might contribute to uncertainty in our consumption and emissions data. We examine the impact this uncertainty by performing numerous robustness checks.

[7] We use prices for 2009 for the whole sample since we have reliable price data for 2009 and the price changes were minor in Sweden between 2008 and 2009 -- the change in the consumer price index (CPI) was -0.3 percent.

Now consider our behavioral model. We explore the impact on adult CO_2 emissions from adding children to a two-adult household. Using Ordinary Least Squares (OLS) regression, with heteroscedasticity-consistent (Huber-White) standard errors, we estimate the following model:

Total CO2 emissions per household (kg) = constant + b1 Number of children 0-6 years*
*+ b2*Number of children 7-12 years*
+ b3 Number of children 13-17 years*
+ b4 Number of children 18-19 years*
+ b5 Two adults without children*
+ b6 One adult without children*
+ b7 One adult with one or more children*
+ b8 Age of the oldest person in the household*
+ b9 Disposable income*
+ b10 Disposable income squared + error term*

Our coefficient of prime interest is *b5*—two adults without children. Given that we control for the impact on CO_2 emissions in the household, *b5* represents the difference in CO_2 emissions from the two adults in a households, caused by adding children to the household. If *b5* is negative, two adults emit less when childless than with children, implying that parents are browner.

We control for age, given that age has been argued to impact environmental preferences – older people will not live long enough to benefit from climate protection (Whitehead, 1991; Carlsson and Johansson-Stenman, 2000). We also control for income since income has been shown to impact CO_2 emissions (see e.g. Richmond and Kaufmann, 2006). We proceed by first examining the consumption that drives our observed differences in total CO_2 emissions. Using the same regression model, we then explore how CO_2 emissions differ for households over consumption subgroups known to contribute heavily to CO_2 emissions – including food consumption (e.g., meat and milk products), transportation, and heating/electricity.

3. Results

Three key results emerge. First, we find that a two-adult household with children does not leave a smaller carbon footprint than a two-adult household without children. To see this result, we first focus on total CO_2 emissions. Using the results from our behavioral model, we see that the average Swedish two-adult household with children emits more carbon—not less—than the comparative household without children. Table 5 shows the specifics—we see 719.21 kg *less* CO_2 emissions for the household without children. This coefficient is substantial in magnitude and statistically significant (*P*-value = 0.001). The average couple of adults in households with children emitted 3,512.07 kg CO_2 annually, the childless household emitted 3,512.07-719.21 = 2792.86. This is 26% percent increase in CO_2 emissions, which suggests that adults go *browner* when having children.

Table 5 further suggests that a household consisting of only one adult without children, annually emits 3512.07-2331.52 = 1180.55, which is less than half of emissions of the two-adult household without children. The Swede with the smallest carbon footprint appears to be someone who lives alone and has never had children.

Second, focusing now on children, our results suggest that each child (ages 7-17) contribute substantially to household CO_2 emissions, as suggested by the large coefficients with high statistical significance (*P*-value = 0.000). This confirms previous findings on the increase in CO_2 emissions resulting from children (see e.g., Wynes and Nicholas, 2017). The impact on household CO_2 emissions from children age 0-6, however, is both smaller in magnitude and less statistically significant (*P*-value = 0.094). For most of the expenditure groups in our data, children of ages 7-17 seem to have a largest impact on CO_2 emissions, compared to younger (ages 0-6) or older children (ages 18-19). The exception is electricity and heating (see Table 10). Small children positively affect CO_2 emissions from electricity and heating, while older children either have no, or possibly a negative impact, on CO_2 emissions from this expenditure group.[8]

Third, we find that the two major sources of consumption that causes adults to increase CO_2 emissions with children are *food and transportation*. For food, Table 6 shows that adults without children annually emit 303.97 kg less of CO_2 from food than do adults with children (*P*-value=0.001). Increased CO_2 emissions from food therefore seems to correspond to 303.97/719.21*100 = 42 percent of the total difference in CO_2 emissions between adults with and without children. Table 6 also shows that the two adults in a household with children annually emit 1028.39 kg CO_2 from food consumption, while a corresponding household without children emits 1028.39 - 303.97 = 724.42. This suggests adult CO_2 emissions from food increases by as much as 42 percent, when children are added to the household. Table 7 shows that an important part of why CO_2 emissions from food increase is increased emissions from *meat* consumption. A two-adult household without children emits 121.90 kg less of CO_2 from meat consumption than does two adults with children (*P*-value=0.043).[9]

For transportation, Table 8 shows that a two-adult household without children annually emit 397.55 kg less of CO_2 compared to two adults with children. This corresponds to 55% of the total difference in CO_2 emissions (= 397.55/719.21*100). Two-adult household with children annually emit 1376.32 kg CO_2 from transportation, while a corresponding household without

[8] Both variables age of the oldest person in the household and disposable income have the expected positive impact on household CO_2 emissions, on overall emissions and on emissions from sub-groups of consumption. The only sub-group for which age and disposable income seems to have no impact on CO_2 emissions is electricity and heating. Note that CO_2 emissions from food only is based on LCA, due to difficulties in finding LCA CO_2 emissions data for the other product groups. This likely means both the reported total CO_2 emissions in Tables 1-2 are on the lower end, as is our result on the difference in CO_2 emissions between parents and non-parents.

[9] Although regression results are not reported here, we also examined if some of the increase in adult CO_2 emissions caused by adding children to the household could be due to increased CO_2 emissions from milk and cheese consumption. We found weak evidence that adult emissions from milk increase from adding children to the household, by an annual increase of 23 kg CO_2 (*P*-value = 0.080), while we could not reject the null that CO_2 emissions from cheese consumption remains the same when children are added to the household (*P*-value = 0.292).

children emits 1376.32 - 397.55 = 978.77. This suggests adult CO_2 emissions from transportation increases by 41 percent, when children are added to the household. Table 9 shows that most of CO_2 emissions from transportation, and differences between parents and non-parents in two-adult households, result from CO_2 emissions from gasoline.

For heating/electricity, Table 10 shows we cannot reject the hypothesis that adult CO_2 emissions from heating/electricity remains the same after children are added to the household (*P*-value = 0.774). Our model fails to explain much of variations in heating/electricity and heating, as implied by the low adjusted R-squared value (0.008).[10]

Finally, we considered the robustness of our main results by considering three aspects of sensitivity—age of household, significance uncertainty and expenditures on package trips. For age, we exclude retired subjects to reduce 'contamination' of our data for households without children from childless households with adult children. In the robustness check we lower the age of the oldest adult in the household to 65, 55 and 45 year. Although our total sample size drops, we see no change in our basic result that parents have a larger carbon footprint. Appendix B provides the details. For uncertainty, we examine four potential sources of variability: (a) CO_2 emissions from boat trips (emissions from a cruise Stockholm-Helsinki), (b) energy usage from district heating (15 percent of rental costs), (c) CO_2 emissions from gasoline (2.24 kg/liter gasoline), and (d) the price of public transportation (calculated as long-distance trips, suggesting the price may be on the lower end). Overall, we find no substantial impact on our main results in any of the four sources of uncertainty—again our results remain robust (see Appendix B for specifics). For expenditures on package trips, Table 11 shows that a two-adult household without children spend SEK 3356.52

[10] Our results remain unchanged if we exclude clothes and footwear, suggesting this expenditure group both has a minor impact on overall CO_2 emissions, and that parents' CO_2 emissions from clothes and footwear in two-adult households do not differ from those of non-parents.

more on international package trips annually compared to two adults in a household with children (*P*-value 0.043). Travel surveys indicate that about 1/3 of the expenditures are spent on transportation (SAEG, 2016). This suggest that a two-adult household without children emit 207.6 kg more of CO_2 compared to two-adults in a household with children, if one assume that all travel related expenditures are spent on gasoline. This implies our main results still hold even if parents seem to substitute to domestic trips from international trips. The Appendixes provide more information about Swede's international trips and CO_2 emissions.

Our data allows us to compare CO_2 emissions of parents versus non-parents. In theory, a self-selection issue could exist, i.e., people who are less "green" might self-select into parenthood. This would imply that our above findings of a larger footprint by parents would not be due to parenthood increasing one's carbon footprint—rather it is the increased footprint that leads to parenthood. But this is unlikely, given that some of the childless households in our data likely will have children later in life, some are involuntarily childless (just like some households with children likely did not plan to have children), while some actively chose to remain childless. Any self-selection affecting our results only pertains to the latter group—those choosing never to have children. A report by Statistics Sweden (2009) finds that this is a small group—of childless households age 20-40, only five percent state they do not want to have children. In contrast, the average young Swedish childless two adult-households plan to have children in the future. And over 50 percent of older childless households said they tried, but failed to have children.

4. Concluding remarks

Becoming a parent can transform a person—he or she thinks more about the future and worries about future risks imposed on their children and progeny. But the open question that we explore herein is whether this transformation means that a person will become greener. Do parents have a smaller carbon footprint? Using a unique data set that allows us to compare CO_2 emissions from Swedish two-adult households with and without children, we find that two adults in households with children increase CO_2 emissions by more than 25 percent relative to two adults in households without children. Parents CO_2 emissions increased due to increased transportation and changed food consumption. While having children might be transformational, our results suggest their "new" preferences did not cause them to reduce their use of carbon. Rather Swedish parents seem to use carbon-based consumption as a substitute for their tighter time constraints. In addition, our results suggest that parents' preferences shift to browner food. We speculated that our Swedish household results represent a lower bound on the parental carbon footprint relative to other countries. Most Swedes tend to believe climate change is a reality and the Swedish government subsidizes childrearing to help reduce time constraints.

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Table 1. Descriptive statistics

	All households		*Two adults with children*		*Two adults without children*	
Variable	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
No of children	1.20	1.16	2.01	0.85		
No of children age 0-6	0.42	0.71	0.74	0.82		
No of children age 7-12	0.36	0.65	0.60	0.76		
No of children age 13-17	0.31	0.62	0.49	0.72		
No of children age 18-19	0.11	0.33	0.17	0.40		
Two adults w. children	0.22	0.41				
One adult w/o children	0.17	0.38				
One adult w. one or more children	0.08	0.27				
Age oldest in household	43.74	11.21	42.20	7.67	48.43	14.08
Disposable income	429.82	231.25	513.87	220.73	452.90	209.41
CO_2 consumption[a]	6890.66	3,390.68	8,229.96	3,225.50	6,736.47	2,929.05
CO_2 food	2,287.74	1,398.22	2,853.27	1,404.37	2,109.04	1,050.36
CO_2 meat	898.48	835.83	1,119.54	914.09	871.17	702.72
CO_2 transportation	3,310.89	2,592.19	4,034.21	2,622.38	3,394.34	2,483.45
CO_2 gasoline	3,168.84	2,608.75	3,893.71	2,640.37	3,179.53	2,502.84
CO_2 electricity & heating	905.40	785.46	916.48	902.31	891.55	789.93
Living area (in m^2)	114.68	51.22	133.37	45.32	112.09	52.69
Cost all-inclusive trip[b]	14,526.05	21,682.23	15,875.86	23,233.67	18,592.28	23,158.15
Cost domestic trip[b]	508.67	2,362.67	579.79	2,727.21	574.66	2,401.66
Cost international trip[b]	13,974.72	21,235.52	15,217.50	22,631.24	18,017.62	22,893.25
N	2,692		1,422		582	

[a]Total CO_2 emissions from consumption included in our analysis (food, transportation, electricity and heating). [b]In SEK.

Table 2. Descriptive statistics, continued

Variable	*One adult with children* Mean	Std.Dev.	*One adult without children* Mean	Std.Dev.
No of children	1.71	0.72		
No of children age 0-6	0.31	0.59		
No of children age 7-12	0.49	0.70		
No of children age 13-17	0.65	0.74		
No of children age 18-19	0.26	0.46		
Two adults w. children				
One adult w/o children				
One adult w. one or more children				
Age oldest in household	42.75	7.95	43.00	15.26
Disposable income	266.54	153.73	221.59	126.88
CO_2 consumption[a]	5,122.00	2,300.84	3,799.24	2,219.89
CO_2 food	1,791.57	1,217.89	1,021.86	680.99
CO_2 meat	614.66	664.28	392.59	466.56
CO_2 transportation	2,001.01	1,719.22	1,704.92	1,922.69
CO_2 gasoline	1,827.92	1,746.64	1,577.12	1,946.73
CO_2 electricity & heating	1,080.31	549.68	806.98	365.16
Living area (in m^2)	97.13	36.52	69.23	38.74
Cost all-inclusive trip[b]	8,860.53	16,295.40	7,987.81	13,760.61
Cost domestic trip[b]	267.69	1,064.52	322.56	1,313.79
Cost international trip[b]	8,578.58	16,239.89	7,665.25	13,580.67
N	219		467	

[a]Total CO_2 emissions from consumption included in our analysis (food, transportation, electricity and heating).
[b]In SEK.

Table 3: CO_2 emissions from food

COICOP	*Good*	*Kg CO_2 per kg/liter good*		*COICOP*	*Good*	*Kg CO_2 per kg/liter good*
	Bread and cereals				*Oils and fats*	
0111101	Rice	2		0115101	Butter	8
01112	Bread	0.8		0115102	"Diet" butter	4.8
0111301	Pasta	0.8		0115201,	Margarine	1.5
0111409	Sandwich	1.5		0115202,		
0111501	Flour	0.6		0115203,		
0111503	Cereal	0.8		0115204		
0111504	Cookies	1		01153	Olive oil	1.5
0111505	Pastries	1		01154	Cooking oil	1.5
0111508	Pizza	2			Mayonnaise	
	Meat				*Fruit & vegetables*	
01121, 0112501	Beef	26		0116	Fruit	0.52[a]
01122, 0112502	Pork, bacon etc.	6		0117	Vegetables	1[b]
01123	Sheep	21		01177	Potato	0.1
01124, 0112503	Poultry	3		0117803	Potato chips	2
0112505	Brawn	7				
0112506	Sausages	6			*Sugar, jam, candy*	
0112507	Pâté	7		01182	Jams, marmalades	3
0112508	Charcuterie	7		01183, 01184	Chocolate, candy etc.	2
0112601	Ready meals	10.6		01185	Ice cream	2
				0119401	Snacks	1
0113	*Fish*	3				
	Milk, cheese, eggs				*Non-alcoholic beverages*	
01141, 01142	Milk	1		01211	Coffee	3
0114401	Yoghurt	1		01221	Table water	0.3
0114402	Sour milk	1		01222	Soda	0.3
011460101, 011460102, 011460103	Cream	4		01223	Fruit juices	3
011450101, 011450102	Cheese	8				
0114701	Eggs	2		111	Restaurants	*c*
0114502, 0114503, 0114504, 0114603	Other dairy products	2				

Note: [a]CO_2 emissions for fruit produced in the Nordic countries = 0.2 kg/(kg fruit), for imported fruit from non-Nordic countries = 0.6. kg/(kg fruit). 20% of the fruit consumption is assumed to be domestically produced, corresponding to the expenditure share on apples. [b]CO_2 emissions for domestically produced root crops = 0.2 kg/(kg root crop); vegetables produced in the Nordic countries = 1.0 kg/(kg vegetables); imported vegetables from non-Nordic countries = 1.4 kg/(kg vegetables); imported vegetables with aircraft = 11 kg/(kg vegetables). [c]CO_2 emissions based on expenditure shares (Carlsson, Palm and Wadeskog, 2006).

Table 4: CO_2 emissions from clothes, electricity, heating and transportation

COICOP	*Good*	*CO_2*		*COICOP*	*Good*	*CO_2*
03	*Clothing and footwear*	*D*			*Transport*	
	Electricity and heating			0722101,	Petrol/Diesel	2.24 kg/liter
0451	Electricity	20 kg/MWh		0722102		(2.6 kg/liter)
0453	Liquide fuels (oil)	2.69 kg/liter		0731	Railway	0
0454	Solid fuels (pellets)	6 kg/MWh		0732	Bus, Taxi	79 g/passenger km
0455	District heating	92.7 kg/MWh		0733	Air	130 kg per trip [e]
				0734	Boat	2.24 kg/liter gasoline [f]
				0735	Combined transport	30 g/passenger km

Note: [d]CO_2 emissions based on expenditure shares (Carlsson, Palm and Wadeskog, 2006). [e]Households with positive expenditures on air travel are assumed to emit 130 kg of CO_2, corresponding to a round trip Stockholm-Gothenburg (the two largest cities in Sweden). [f]Expenditures are assumed to be on gasoline. In the sensitivity analysis we assume all households with positive expenditures on boat travel have made a round trip Stockholm-Helsinki, the most common boat trip for Swedes (CO_2 emissions are 180 kg per trip).

Table 5. Regression results, total CO_2 emissions

Variable	Parameter estimate	Standard error	P-value
Constant	3512.07	335.97	0.000
Number of children 0-6 years	187.60	111.86	0.094
Number of children 7-12 years	422.63	102.23	0.000
Number of children 13-17 years	502.11	113.33	0.000
Number of children 18-19 years	203.11	189.83	0.285
Two adults without children	-719.21	220.12	0.001
One adult without children	-2331.52	247.55	0.000
One adult with one or more children	-1885.69	229.34	0.000
Age of the oldest person in the household	28.82	5.43	0.000
Disposable income	6.84	0.62	0.000
Disposable income squared	-0.002	0.0003	0.000
N	2,680		
Adjusted R-square	0.33		

Dependent variable: Annual CO_2 emissions

Standard Errors computed from heteroscedastic-consistent matrix

Table 6. Regression results, CO_2 emissions from food

Variable	Parameter estimate	Standard error	P-value
Constant	1028.39	138.10	0.000
Number of children 0-6 years	87.73	46.05	0.057
Number of children 7-12 years	177.86	42.11	0.000
Number of children 13-17 years	365.02	46.66	0.000
Number of children 18-19 years	322.20	78.12	0.000
Two adults without children	-303.97	90.59	0.001
One adult without children	-924.35	101.78	0.000
One adult with one or more children	-669.86	94.33	0.000
Age of the oldest person in the household	10.51	2.23	0.000
Disposable income	2.30	0.26	0.000
Disposable income squared	-0.007	0.001	0.000
N	2,692		
Adjusted R-square	0.33		

Dependent variable: Annual CO_2 emissions from food consumption
Standard Errors computed from heteroscedastic-consistent matrix

Table 7. Regression results, CO_2 emissions from meat consumption

Variable	Parameter estimate	Standard error	P-value
Constant	295.61	91.64	0.001
Number of children 0-6 years	-16.92	30.56	0. 580
Number of children 7-12 years	35.46	27.94	0.204
Number of children 13-17 years	128.37	30.96	0.000
Number of children 18-19 years	96.84	51.84	0.062
Two adults without children	-121.90	60.11	0.043
One adult without children	-333.47	67.54	0.000
One adult with one or more children	-281.13	62.59	0.000
Age of the oldest person in the household	3.57	1.48	0.016
Disposable income	1.35	0.17	0.000
Disposable income squared	-0.0004	0.0001	0.000
N	2,692		
Adjusted R-square	0.17		

Dependent variable: Annual CO_2 emissions from meat consumption
Standard Errors computed from heteroscedastic-consistent matrix

Table 8. Regression results, CO_2 emissions from transportation

Variable	Parameter estimate	Standard error	P-value
Constant	1376.32	284.90	0.000
Number of children 0-6 years	88.84	95.00	0.350
Number of children 7-12 years	285.02	86.87	0.001
Number of children 13-17 years	159.12	96.25	0.098
Number of children 18-19 years	3.43	161.16	0.983
Two adults without children	-397.55	186.88	0.033
One adult without children	-1350.25	209.97	0.000
One adult with one or more children	-1464.56	194.60	0.000
Age of the oldest person in the household	23.79	4.60	0.000
Disposable income	3.27	0.53	0.000
Disposable income squared	-0.001	0.0003	0.000
N	2,692		
Adjusted R-square	0.17		

Dependent variable: Annual CO_2 emissions from transportation
Standard Errors computed from heteroscedastic-consistent matrix

Table 9. Regression results, CO_2 emissions from gasoline

Variable	Parameter estimate	Standard error	P-value
Constant	1170.88	287.32	0.000
Number of children 0-6 years	127.99	95.81	0.182
Number of children 7-12 years	314.44	87.61	0.000
Number of children 13-17 years	177.97	97.07	0.067
Number of children 18-19 years	6.58	162.52	0.968
Two adults without children	-383.57	188.47	0.042
One adult without children	-1326.90	211.75	0.000
One adult with one or more children	-1488.90	196.25	0.000
Age of the oldest person in the household	26.03	4.64	0.000
Disposable income	3.08	0.53	0.000
Disposable income squared	-0.001	0.0003	0.000
N	2,692		
Adjusted R-square	0.16		

Dependent variable: Annual CO_2 emissions from gasoline
Standard Errors computed from heteroscedastic-consistent matrix

Table 10. Regression results, CO_2 emissions from electricity and heating

Variable	Parameter estimate	Standard error	P-value
Constant	797.02	94.18	0.000
Number of children 0-6 years	65.89	31.41	0.036
Number of children 7-12 years	-1.19	28.72	0.967
Number of children 13-17 years	20.48	31.82	0.520
Number of children 18-19 years	-96.43	53.28	0.070
Two adults without children	17.71	61.78	0.774
One adult without children	-42.42	69.41	0.541
One adult with one or more children	217.95	64.33	0.001
Age of the oldest person in the household	0.56	1.52	0.712
Disposable income	0.15	0.18	0.398
Disposable income squared	-0.00007	0.00009	0.425
N	2,692		
Adjusted R-square	0.008		

Dependent variable: Annual CO_2 emissions from electricity and heating
Standard Errors computed from heteroscedastic-consistent matrix

Table 11. Regression results, expenditures on outbound tourism (package trips)

Variable	Parameter estimate	Standard error	P-value
Constant	-1830.11	2547.79	0.473
Number of children 0-6 years	-2788.84	840.11	0.001
Number of children 7-12 years	-612.77	732.48	0.403
Number of children 13-17 years	418.05	846.24	0.621
Number of children 18-19 years	985.81	1518.69	0.516
Two adults without children	3356.52	1656.25	0.043
One adult without children	1885.98	1752.45	0.282
One adult with one or more children	1557.09	1510.66	0.303
Age of the oldest person in the household	-61.52	37.10	0.097
Disposable income	50.06	5.68	0.000
Disposable income squared	-0.013	0.003	0.000
N	2,692		
Adjusted R-square	0.115		

Dependent variable: Total expenditures on outbound tourism COICOP 09602 (package holidays). Standard Errors computed from heteroscedastic-consistent matrix.

Appendix A - Data

We begin by describing how we calculated household CO_2 emissions. We first estimated household quantities consumed of goods and services and then matched consumption data with corresponding CO_2 emissions. We used household expenditure data from Statistics Sweden for 2008-2009, classified according to the COICOP classification system. Statistics Sweden samples 4,000 households in which at least one person was of age 0-79 years old. Statistics Sweden draws a random sample of households over the 52 starting weeks of household participation. Participates keep a diary for 14 days (or, alternatively, report receipts directly to Statistics Sweden) and are interviewed via phone. Statistics Sweden has matched participating households with register data on disposable income (including both labor income and government transfers).

We limit our sample in a couple of important ways. First, we restrict our sample to households consisting of two adults (only), who have a positive household disposable income. Second, we exclude households in which at least one household member is retired. We make this restriction given we aim to address the impact on CO_2 emissions of adults from adding children to the household, and not from removing them. We want to minimize the amount of households in our sample consisting of adults who once lived with children but not now (since we assume all households in our analysis that are currently childless also never had children).[11]

Our data contains detailed expenditure information on goods and services that constitute the vast majority of household CO_2 emissions, classified according to the international COICOP classification system on a four-digit level. This captures detailed expenditures of food groups (including alcoholic and non-alcoholic beverages), transportation, clothing (including shoes) and housing. Tables 3 and 4 show expenditure groups in the data and associated levels of CO_2 emissions.

We calculated quantities consumed by dividing expenditures by 2009 prices for all expenditure items.[12] We then matched each item with their CO_2 emissions per unit. We used several different data sources for this matching. Below, we describe in detail the data used for each

[11] We can only speculate in how adult preferences may be affected, if at all, when children leave the household -- we are open to the idea that this is yet another transformational experience for parents.
[12] We use prices for 2009 for the whole sample since we have reliable price data for 2009 and the price changes were minor in Sweden between 2008 and 2009 -- the change in the consumer price index (CPI) was -0.3 percent.

broader expenditure category (food, transportation, clothing and housing), starting with the larger expenditure categories.

Food and non-alcoholic beverages. To calculate quantities consumed of food items consumed at home, we have used detailed price data entailed in Consumer Price Index, collected by Statistics Sweden. For food consumed at home, we use CO2 emissions reported by Röös et al. (2014). These calculations are based on life cycle analysis (LCA). For food consumed away from home, households in the expenditure survey do not specify individual items purchased. For this group of food consumption, we use the CO2 emissions calculated by Statistics Sweden (Carlsson, Palm and Wadeskog, 2006) in their environmental accounts, which is based on expenditure shares of food away from home.

Clothing and footwear. For this expenditure category, we use CO2 emission data from Statistics Sweden. Households do not specify individual items purchased of clothes and shoes. For this expenditure group, as with food away from home, we therefore use Statistics Sweden's (Carlsson, Palm and Wadeskog, 2006) specification of CO2 emissions based on expenditure shares.

Heating and electricity. The electricity price is based on the average 2009 electricity spot price[13] plus taxes. We use CO2 emissions from electricity as calculated by Swedenenergy (1 kWh emits 20g CO2).[14] Energy usage (district heating) for households in apartments (rental or own) is calculated as a fixed percentage (15 percent) of their rental cost (Silverfur and Sjöberg, 2015). Prices for district heating, both for apartments and single-family homes, are based on data from a market survey by 'Energiforetagen'.[15] Prices for pellets in 2009 varied between (SEK0.50-0.70/kwh), as reported by Lapplands Kommunalforbund (Energi- och Klimatradgivning). We use the average price (i.e., SEK0.60/kwh). CO2 emissions from pellets are from The Swedish Association of Public Housing Companies (SABO), also stated per Kwh.[16] Both the oil price and CO_2 emissions from oil is from the Swedish Petroleum and Bio Fuel Institute (Svenska Petroleum

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[13] Reported by Fortum: https://www.fortum.com/countries/se/privat/el/elmarknaden/historiska-elpriser/pages/default.aspx.

[14] https://svenergi52iskprod.dxcloud.episerver.net/sa-fungerar-det/miljo-och-klimat/elen-och-miljon/klimatpaverkan-och-vaxthusgaser/. We use the figure for a normal year with electricity production based on domestic production (hydropower and nuclear power).

[15] See link https://www.energiforetagen.se/statistik/fjarrvarmestatistik/fjarrvarmepriser. The link entails prices for 2014 and 2015. Prices used in our analysis are revised for 2009, using price indices for district heating. Prices are higher for district heating in single family homes, compared to prices of district heating in apartments, due to price variations over the size of district heating customers.

[16] http://www.sabo.se/kunskapsomraden/energi/Sidor/Miljovardering.aspx.

& Biodrivmedel Institutet).[17] Although commonly used in many other countries, natural gas is a highly uncommon energy source in Sweden and therefore not part of our data.

Transportation. Most of transportation pertains to car trips, meaning CO_2 emissions mainly pertain to car fuel (primarily gasoline, but also diesel and other fuels, like ethanol). In our sample, 86.1 percent of households report expenditures on car fuel. To calculate CO_2 emissions from car transports, we again use prices and CO_2 emissions from the Swedish Petroleum and Bio Fuel Institute (Svenska Petroleum & Biodrivmedel Institutet), see previous footnote. The average gasoline price in 2009 was SEK12.06/liter. For bus, taxi and domestic train transports, we use CO_2 emissions from The Swedish Public Transport Association. CO_2 emissions for buses differ depending on if the bus is part of the public transport system and if the bus is a (often long-distance) travel mode (where taxi also is included in the expenditure survey). Following The Swedish Public Transport Association, domestic train trips in Sweden are assumed to emit no CO_2.[18] Prices for bus trips are based on price in SEK/km, for a variety of short and long distance trips. The lower price interval bound is almost the same as the gasoline price/litre, which we choose to use in the main analysis, while performing robustness checks where the bus transport price is increased. We do not use prices for flights or boat trips, but calculate CO_2 emissions directly by assuming that the flight trip is a domestic flight in Sweden, between the two major cities (Gothenburg and Stockholm).[19] CO_2 emissions for boat trips are based on CO_2 emissions from a cruise Stockholm-Helsinki.[20] Only 2.1 percent of our sample reports expenditures for boat trips, and only 0.9 percent of the sample households report expenditures on flight transportation. These low numbers likely result from the method by which data is collected – to report expenditures on boat or flight trips, those trips must have been undertaken by the household during the two weeks of dairy reporting. Expenditures on package trips (COICOP 096) are collected by interviews, and refers to expenses over the past 12 months. Twelve percent of the sample report expenditures on domestic package tours and 52.6 percent report expenditures on international package tours. According to the Swedish national travel survey RES 2005-2006 (SIKA 2007), the Swede's made 13,5 million international trips in 2006. Of these, 24 percent were shorter trips (less than 100 kilometers) to neighboring countries. Denmark, Finland, Norway, Germany and Spain were the most visited

[17] http://spbi.se/blog/faktadatabas/artiklar/berakningsmodeller/
[18] All trains in Sweden run on electricity. Swedish electricity is produced using non-fossil fuels.
[19] http://www.klimatbalans.se/neutralisera/resor.html
[20] http://www.utslappsratt.se/berakna-utslapp/berakning-av-utslapp-fran-batar-och-fartyg/

countries. The nine most popular destinations were all European countries, USA was the tenth most popular destination. Three fourth of the trips lasted for more than one day. Trips with a duration more than one day, hade on average a duration of seven days. The most common type of accommodation were hotels. Based on aggregate data on number of trips and mode of transport to the ten most visited countries, own calculations show that the average transport emissions per trip amounts to 153 kg CO_2.

Although flights emit substantial CO_2 per kilometer, road transportations constitute the absolute majority of transports, such that flight CO_2 emissions are only a minor share of total emissions from transportation. The Swedish Environment Protection Agency estimates that greenhouse gases from all flight transports (i.e., private, public and commercial) constituted 2.8 percent of total greenhouse gas emissions in 2015, compared to 93.8 from road transports.[21]

[21] http://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaser-utslapp-fran-inrikes-transporter/

Appendix B – Robustness checks

We examine whether excluding all subjects of age 65 and older impacts our results.[22] Now our total sample size drops to 2,614 from 2,692. We see our main result remains robust. For instance, if we use this reduced sample to replicate the regression in Table 3, we find that two adults in a household with children annually emit 3207.94 kg CO_2, while a childless household with two adults annually emits 3207.94 -667.43 = 2,540.502. The coefficient for the childless two-adult household is both large (-667.43) and statistically significant (*P*-value = 0.003), and implies that, when excluding subjects 65 years and older, becoming parents increases a two-adult household's annual emissions of CO_2 by 26.27 percent (i.e., somewhat higher than the 25 percent reported in our main analysis). To further check the robustness of our result with respect age, we estimate models where the oldest individual in the household has an age below 55 and 45 year. The main result also remains robust for these regressions. When the oldest individual in the household has an age blow 55 years the coefficient for the childless two-adult household is -663.09 (*P*-value 0.01), and when the age is below 44 years the coefficient is -607.67 (*P*-value 0.05).

For CO_2 emissions from boat trips, we estimate our model based on the assumption that expenditures on boat trips consists of fuel (gasoline) for privately owned boats by the households, instead of assuming expenditures on boat trips consists of a cruise Stockholm-Helsinki. This marginally impacts our overall results – we then find that parenthood increases CO_2 emissions by 25 percent, i.e., a somewhat smaller percentage change than the 25.75 percentage change reported in our main analysis. Although marginal, the only noteworthy on impact our results is that the difference in CO_2 emissions from transportation between parents and non-parents in two-adult households becomes somewhat less significant. The estimated coefficient for the difference in CO_2 emissions between two adults without children increases some in magnitude and its associated *P*-value increases to 0.049 (compared to 0.033 in our main analysis, see Table 6). We in turn examined how sensitive the results were to assumptions made for energy usage from district heating, CO_2 emissions from gasoline and the price of public transportation.

For energy usage from district heating, we calculate household energy usage from district heating as a fixed percentage of 20 percent of their rental cost, instead of 15 percent, and find our results are almost unchanged. With this revision to our data, the difference in overall CO_2

[22] We find, however, that some household members work past their retirement age, increasing the risk of including households in our sample who currently are childless, but previously had children.

emissions between parents and non-parents increases by a modest 3 kg/year, while the difference in CO_2 emissions from heating and electricity remains non-significant, as reported below.

For CO_2 emissions from gasoline, we estimate our model based on the assumption that gasoline emits 2.6 kg of CO_2 per liter (the CO_2 emission per liter of diesel fuel), instead of the assumption in our main analysis of 2.24 kg of CO_2 per liter. This revision to our data has a margin impact on our results. The absolute difference in CO2 emissions between adults in a two-adult household with and without children increases to 781.2 annual CO_2 emissions. Note, however, the observed absolute value of emissions from the parents also increases, resulting in an overall increase in CO_2 emissions from parenthood of 27 percent. This does not contradict our main finding that adults with children have a larger footprint. Emissions from the sub-group transportation itself are similarly marginally affected.

For the price of public transportation, we estimate our models increasing the price of public transportation by as much as 5 and 10 times. This does not impact our main results at all, even when the price is multiplied by a factor of 10. It also has a marginal effect on the results for the sub-group transportation.

For expenditures on package trips we estimate the same behavioral model as for CO_2 emissions, see Table 11. Since package trips include a number of services such as traveling and accommodation, and we lack more specific information in the expenditure survey, we use expenditures as the dependent variable in the regression model. For expenditures on domestic package trips there is no significant difference in expenditures between two-adult households with and without children[23], but for international package trips the regression results suggest that two-adult households without children spend SEK 3357 more than two-adult households with children. Calculations in the data Appendix indicate that one international trip emits about 153 kg CO_2. Surveys on Swedes expenditures on domestic tourism (SAEG, 2016) show that about one third of the expenditures are on transportation. If we assume that 1/3 of the SEK 3357 are spent on gasoline[24] a two-adult households without children would emit 207.6 kg more CO_2 than two-adult households with children on international package trips. If we assume that 50% are spent on gasoline, CO_2 emissions would increase to 311.7 kg. This number is still lower than the difference in CO_2 emissions between two-adult households (397.55 kg) that we estimate for transportation.

[23] The estimated difference in expenditure is SEK 16 ($2).
[24] The price on gasoline was SEK 12.06 per liter in 2009.

Although parents seem to substitute from international trips to domestic trips our main result still remain.

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