

How Age and Gender Affect the Carbon Footprint of the Population in Croatia

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Abstract—The term carbon footprint refers to the amount of carbon dioxide equivalent (CO₂) released into the atmosphere through daily activities. The goal of the European Union is to become climate neutral by the 2050, i.e., to achieve carbon neutrality, which means achieving a balance between carbon emissions and its absorption from the atmosphere into carbon sinks. With the guidance of the Green Plan, by 2050, Europe is to become the first continent to eliminate as much CO₂ emissions as it produces. Global annual CO₂ growth is 1.4%. According to data from 2016, global scale of emissions was around 50 billion t/y. of CO₂ (an increase of 40% compared to 1990). Croatia emitted 17.88 million tons of CO₂ and EU emitted total of 2.92 billion tons. While carbon footprint can be reduced by improving energy efficiency and changing lifestyles and habits much of it depends on personal characteristics of individuals and societal values, age, gender, place of residence and habits are elaborated in this paper. Statistical methods were used to process and analyze the results.

Keywords—climate neutrality, generational division, descriptive statistics, *t*-test

I. INTRODUCTION

By definition, the carbon footprint means the amount of carbon dioxide (CO₂) emissions associated with all the activities of an individual or any other entity (e.g., state, infrastructure, industry...). This equivalent of carbon (IV) oxide includes direct emissions, mostly caused by the burning of fossil fuels in transport, heating, production, etc., and emissions necessary for the production of electricity for wide consumption of goods and services. By introducing the term carbon footprint, scientists set factors and provided a mathematical calculation of the amount of carbon dioxide that each of the mentioned entities indirectly or directly emit into the atmosphere through their activities [1]. By personal choice, individuals can impact the extent of the damage to the environment, and the effects it'll have on the climate change in the future. Choosing energy from renewable sources, ecologically sustainable types of transport, ecological and reusable packaging, food choices, recycling and general decrease in consumption can reduce personal carbon footprint. Since personal choices could be to a great extent influenced by habits and tradition, it is essential to know how those habits and tradition differ when different socio-demographic and socio-economic factors are taken into consideration. Therefore, this paper examines influence of gender and age on personal habits and choices of respondents.

II. GENERATIONAL DISTRIBUTION

Strauss, Strauss and Howe [2] divided cohorts of American

population into generations that share the same environmental, cultural and other circumstances, thus growing up to form specific views of the world in general and develop comparable needs and habits, as well as their attitude towards specific issues. Of those generations, according to their taxonomy, following generations are covered in this research:

- Baby-boom,
- Generation X,
- Generation Y and
- Generation Z.

The baby boom generation includes those born between 1945 and 1964. They were raised with the idea that if they work hard they will get what they want. They are the first generation to engage in peaceful civil disobedience to rally for peace, equal rights, civil rights, women's rights, and environmental concerns. They organized and celebrated the first Earth Day in 1970. They are the first green generation - pioneers [3].

Generation X [4] includes those born between 1960 and 1980. In their youth, they watched the fall of the Berlin Wall, witnessed the IT revolution and the development of mobile technology. They know both the analog and digital age. In Croatia, they are the drivers of change when it comes to environmental protection. The first laws related to environmental protection and waste management in the Republic of Croatia were passed in the 90s [5].

Generation Y or Millennials includes those born between 1980 and 2000. The first IT generation, which, while growing up, began to also live virtually, in various digital spaces and applications. They grew up in a world where everything changes rapidly so they do not resist changes but see them as a means of progress. Despite the fact that they inherited a planet with uncertain future, they believe in and work on methods to change the world for the better [5, 6].

Generation Z includes those born since 2000. Their main characteristic is that they grew up during the Great Recession. In terms of technology, this is the first generation that doesn't even know about a different world than the digital one. They are thrifty, mistrustful of brands, spend time on social networks, shop online and show a collaborative nature. They believe that only the strongest survive and are aware that they will have to fight hard for what they want [4].

III. MATERIALS AND METHODS

During the preparation of the paper, in addition to theoretical research, survey research and statistical data processing were administered. Respondents were surveyed

by an online questionnaire to determine their habits and statistically significant difference between the habits of generations that affect the carbon footprint were found. After the socio-demographic questions, respondents answered to 11 closed questions. Total number of 167 respondents responded to the survey, consisting of 62.9 % of women, and 37.1 % of men, and thus primary, discrete data were collected. Descriptive statistics methods were used for statistical data processing, and t-test was used to test whether there is a statistically significant difference in answers primarily considering the factors of gender and generations.

IV. RESULTS AND DISCUSSION

When asked about the number of household members:

- 29.9% of respondents share a house or apartment with 3 householders,
- 21.6% with 2,
- 20.4% with 1,
- 12% with 4,
- 9.6% that they live alone and
- 6.5% with five or more.

Considering the place of residence:

- 47.9% of respondents live in a medium-sized house,
- 31.7% in an apartment,
- 17.2% in a small house and
- 13.2% in a large house.

When asked about the amount of use of the washing machine:

- 47.9% of respondents use it 4–9 times a week,
- 46.7% 1–3 times a week and
- 5.4% more than 9 times a week.

For the amount of use of a dishwasher:

- 41.9% of respondents answered they use it 4–9 times a week,
- 28.7% of respondents do not have a dishwasher,
- 25.1% 1–3 times a week and
- 4.3% more than 9 times a week.

Regarding the eating habits:

- 71.3% of respondents answered that they eat meat a couple of times a week,
- 23.4% eat meat every day,
- 4.3% are vegetarians and 1% of respondents are vegans.

When asked about shopping habits:

- 62.9% of the respondents buy new furniture, electronics and similar necessities around 3 items a year,

- 22.8% 3–5 items a year,
- 6.2% 5–7 pcs a year,
- 5.1% buy nothing new only used and
- 3% buy more than 7 pcs a year.

Considering the total amount of production of all types of waste:

- 32.3% of respondents produce 1 bucket a week,
- 31.1% 2 buckets a week,
 - 15% less than 1 bucket a week,
- 11.4% 3 buckets a week,
- 10.2% 4 bins a week.

When asked about waste separation:

- 95.8% of respondents' separate plastic,
- 94% paper and cardboard,
- 83.2% glass packaging,
- 71.9% bio-waste and
- 68.3% metal packaging.

When asked about traveling by car:

- 42.5% of respondents travel by car from 1,000–10,000 km/year,
- 29.9% 10,000–15,000 km/year,
- 22.2% more than 15,000 km/year and
- 5.4% less than 1,000 km/year.

Also,

- 87.3% of respondents travel by public transport less than 1,000 km/year,
- 6.4% from 1,000–10,000 km/year,
- 3.4% from 10,000–15,000 km/year,
- 1.7% from 15,000–20,000 km/year and
- 1.3% more than 20,000 km/year.

When asked about the use of airplanes:

- 77.5% of respondents do not travel by airplane,
- 14.8% travel only within the EU,
- 5.1% travel to other continents,
- 2.5% travel long distances.

Following the data collection, each answer is scored and the carbon footprint is calculated. Descriptive statistics results considering gender were shown in Tables 1 and 2.

Using the values from the table, a *t*-test was applied to determine if there is a statistically significant difference between men and women, for a significance level of 5% (Table 3). The degree of freedom is:

$$df = (106 - 1) + (62 - 1) = 166 \quad (1)$$

Table 1. Descriptive statistics of women's responses

Question	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation
Household members	2	14	12	9.60	10	8	7.19	2.68	27.93%
Place of residence	2	10	8	5.54	7	7	8.54	2.92	52.76%
Washing machine	1	3	2	1.53	1	1	0.33	0.57	37.46%
Use of dishwasher	0	3	3	1.21	1	2	0.78	0.88	72.93%
Eating habits	2	10	8	8.11	8	8	2.72	1.51	18.58%
Shopping habits	2	10	8	4.62	4	4	2.01	1.42	30.66%
Waste production	5	50	45	26.75	30	30	172.40	13.13	49.09%
Waste separation	4	20	16	7.43	4	4	22.69	4.76	64.07%
Traveling by car	4	12	8	8.04	6	6	6.55	2.56	31.84%
Public transport	2	20	18	2.77	2	2	6.90	2.63	94.71%
Airplanes flights	0	20	20	2.15	0	0	24.13	4.91	228.37%

Table 2. Descriptive statistics of men's responses

Question	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation
Household members	2	14	12	8.68	8	8	9.30	3.05	35.15%
Place of residence	2	10	8	5.63	7	7	6.83	2.61	46.42%
Washing machine	1	3	2	1.68	2	2	0.39	0.62	37.04%
Use of dishwasher	0	3	3	1.19	1	2	0.95	0.97	81.47%
Eating habits	4	10	6	8.45	8	8	1.1.0	1.05	12.43%
Shopping habits	2	10	8	5.23	4	4	3.72	1.93	36.90%
Waste production	5	50	45	25.16	20	20	150	12.25	48.67%
Waste separation	4	20	16	7.35	4	4	20.04	4.48	60.86%
Traveling by car	4	12	8	9.06	10	12	7.83	2.8	30.87%
Public transport	2	6	4	2.1	2	2	0.32	0.56	26.91%
Airplanes flights	0	20	20	1.84	0	0	25.88	5.09	276.65%

Table 3. T-test of gender differences

Question	Women		Men		S _{WM}	t	Conclusion
	Average	Stand. deviation	Average	Stand. deviation.			
Household members	9.60	2.68	8.68	3.05	0.465	1.978	Statistically significant
Place of residence	5.54	2.92	5.63	2.61	0.436	0.206	Statistically insignificant
Washing machine	1.53	0.57	1.68	0.62	0.096	1.563	Statistically insignificant
Use of dishwasher	1.21	0.88	1.19	0.97	0.150	0.133	Statistically insignificant
Eating habits	8.11	1.51	8.45	1.05	0.198	1.717	Statistically insignificant
Shopping habits	4.62	1.42	5.23	1.93	0.281	2.171	Statistically significant
Waste production	26.75	13.13	25.16	12.25	2.012	0.790	Statistically insignificant
Waste separation	7.43	4.76	7.35	4.48	2.183	0.037	Statistically insignificant
Traveling by car	8.04	2.56	9.06	2.80	0.434	2.350	Statistically significant
Public transport	2.77	2.63	2.10	0.56	0.265	2.528	Statistically significant
Airplanes flights	2.15	4.91	1.84	5.09	0.803	0.386	Statistically insignificant

According to the survey, a statistically significant difference in relation to gender is noticeable in relation to the number of household members, shopping habits and use of car or public transport while all the other factors showed no statistically significant difference.

According to the generational division, descriptive statistics results of the carbon footprint were made, shown in Tables 4–7. Here the obtained results are more intriguing and show bigger difference between groups.

Table 4. Descriptive statistics of baby boom generation's carbon footprint

Question	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation
Household members	14	14	0	14	14	14	0	0	0 %
Place of residence	4	7	3	5.5	5.5	-	4.5	2.12	38.57%
Washing machine	1	1	0	1	1	1	0	0	0 %
Use of dishwasher	0	0	0	0	0	0	0	0	-
Eating habits	8	8	0	8	8	8	0	0	0.00%
Shopping habits	4	4	0	4	4	4	0	0	0.00%
Waste production	5	20	15	12.5	12.5	-	112.5	10.61	84.85%
Waste separation	4	8	4	6	6	-	8	2.83	47.14%
Traveling by car	4	6	2	5	5	-	2	1.41	28.28%
Public transport	2	2	0	2	2	2	0	0	0 %
Airplanes flights	0	0	0	0	0	0	0	0	0 %

Table 5. Descriptive statistics of X generation's carbon footprint

Question	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation
Household members	4	14	10	9.9	10	8	6.64	2.58	26.01%
Place of residence	3	10	7	5.11	7	7	8.2.0	2.86	56.02%
Washing machine	2	3	1	1.51	1	1	0.32	0.56	37.42%
Use of dishwasher	3	1	2	1.35	2	2	0.75	0.86	64.06%
Eating habits	4	10	6	8.06	8	8	2.06	1.44	17.80%
Shopping habits	0	10	10	4.48	4	4	2.29	1.51	33.78%
Waste production	1	50	49	25.48	30	30	169.1	13.0	51.05%
Waste separation	2	16	14	6.22	4	4	9.69	3.11	50.03%
Traveling by car	5	12	7	8.57	10	6	7.8.0	2.79	32.58%
Public transport	4	6	2	2.22	2	2	0.53	0.73	32.77%
Airplanes flights	4	20	16	2.95	0	0	35.85	5.99	202.81%

Table 6. Descriptive statistics of Y generation's carbon footprint

Question	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation
Household members	2	14	12	8.97	10	8	8.23	2.87	31.98%
Place of residence	2	10	8	5.74	7	7	7.50	2.73	47.69%
Washing machine	1	3	2	1.62	2	2	0.35	0.59	36.23%
Use of dishwasher	0	3	3	1.14	1	2	0.82	0.9	79.31%
Eating habits	4	10	6	8.30	8	8	1.56	1.25	15.05%
Shopping habits	2	10	8	5.08	4	4	2.83	1.68	33.15%
Waste production	5	50	45	27.04	30	20	157.2	12.54	46.36%
Waste separation	4	20	16	8.22	4	4	28.30	5.32	64.76%
Traveling by car	4	12	8	8.43	10	6	6.86	2.62	31.06%
Public transport	2	20	18	2.47	2	2	4.21	2.05	82.95%
Airplanes flights	0	20	20	1.44	0	0	15.68	3.96	274.86%

Table 7. Descriptive statistics of Z generation's carbon footprint

Question	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation
Household members	2	10	8	6.67	8	8	6.00	2.45	36.74%
Place of residence	2	10	8	7.44	7	7	6.28	2.51	33.66%
Use of washing machine	1	3	2	1.89	2	2	0.61	0.87	41.39%
Use of dishwasher	0	3	3	1.22	2	0	1.44	1.20	98.33%
Eating habits	4	10	6	8.89	10	10	4.11	2.03	22.81%
Shopping habits	2	8	6	5.33	6	4	4.00	2.00	37.50%
Waste production	5	50	45	25.56	30	30	221.5	14.88	58.24%
Waste separation	4	16	12	8.00	4	4	28.0	5.29	66.14%
Traveling by car	6	12	6	8.00	6	6	6.00	2.45	30.62%
Public transport	2	20	18	5.33	4	2	33.0	5.74	107.71%
Airplanes flights	0	0	0	0.00	0	0	0.00	0.00	-

Using the values from Tables 4–7, a t-test was applied to determine if there is a statistically significant difference between generations. for a significance level of 5%. The degrees of freedom are:

$$df_{BB/X} = (2 - 1) + (63 - 1) = 63 \quad (2)$$

$$df_{BB/Y} = (2 - 1) + (93 - 1) = 93 \quad (3)$$

$$df_{BB/Z} = (2 - 1) + (10 - 1) = 10 \quad (4)$$

$$df_{X/Y} = (63 - 1) + (93 - 1) = 154 \quad (5)$$

$$df_{X/Z} = (63 - 1) + (10 - 1) = 71 \quad (6)$$

$$df_{Y/Z} = (93 - 1) + (10 - 1) = 101 \quad (7)$$

The results are presented in Table 8.

There is a statistically significant difference between:

- Baby boom and generation X in 7/11 questions
- Baby boom and generation Y in 8/11 questions
- Baby boom and generation Z in 5/11 questions
- Generation X and Y in 3/11 questions
- Generation X and Z in 3/11 questions
- Generation Y and Z in 3/11 questions

Descriptive statistics of generation mean values and rank in carbon footprint production are shown in Table 9.

Table 8. T-test of generations' differences

Question	Baby boom/X		Baby boom/Y		Baby boom/Z		X/Y		X/Z	
	S _{BBX}	t	S _{BBY}	t	S _{BBZ}	t	S _{XY}	t	S _{XZ}	t
Nr. of household members	0.325	12.610	0.298	16.902	0.441	9.461	0.441	2.110	0.840	3.844
Place of residence	1.542	0.253	1.526	0.157	0.458	1.144	0.458	1.375	0.872	2.673
Use of washing machine	0.071	7.229	0.061	10.134	0.093	3.235	0.093	1.178	0.284	1.338
Use of dishwasher	0.108	12.46	0.093	12.215	0.143	3.215	0.143	1.469	0.395	0.329
Eating habits	0.181	0.331	0.130	2.314	0.223	1.386	0.223	1.076	0.667	1.244
Shopping habits	0.19	2.523	0.174	6.199	0.258	2.103	0.258	2.326	0.660	1.287
Waste production	7.679	1.690	7.614	1.910	2.091	1.475	2.091	0.746	4.982	0.016
Waste separation	2.039	0.108	2.076	1.069	0.677	0.767	0.677	2.956	1.718	1.036
Traveling by car	1.057	3.377	1.033	3.319	0.444	2.376	0.444	0.315	0.851	0.670
Use of public transport	0.092	2.392	0.213	2.211	0.232	1.835	0.232	1.079	1.817	1.711
Airplanes flights	0.755	3.909	0.411	3.507	0.859	-	0.859	1.758	0.755	3.909

Table 9. Descriptive statistics of the carbon footprint according to generational mean values

Generation	Min	Max	R	Average	Median	Mode	Variance	Stand. deviation	Coeff. of variation	Rank
baby boom	52	64	12	58.00	58	-	72.00	8.485	14.62%	4
X	43	122	79	75.86	74	69	263.96	16.25	21.42%	3
Y	48	119	71	78.45	76	74	276.82	16.64	21.21%	1
Z	53	102	49	78.33	79	-	306.50	17.51	22.35%	2

V. CONCLUSION

There is a statistically significant difference between men and women in relation to the number of household members, shopping habits and use of car or public transport. In conclusion it could be stated that, although the influence of gender on the carbon footprint exists to some extent, apart from the use of means of transportation, no statistically significant difference was found in most examined factors.

The statistical analysis for the generational distribution turned out to be more interesting. It shows that the Baby boom generation has a statistically significant difference in carbon footprint compared to generations X and Y, while compared to the Z generation it has a less significant statistical difference: Baby boomers differ from Generation X in 63.64% of the answers and 72.73% from Generation Y while only 45.45% compared to Generation Z. There is a statistical difference between generations X, Y and Z, but it is not significant since the difference in the answers between all of them (compared to each other) is only 27.27%. Descriptive statistics according to mean values show that the Baby Boom generation has the lowest carbon footprint, followed by Generation X, then Z, ending with the Generation Y having the highest carbon footprint, which leads us to the conclusion that age has a significant impact on the carbon footprint of the population in the Republic of Croatia. A possible explanation is inconclusive and further research is needed to determine the cause of such results but considering the generation theory of Strauss, Strauss and Howe it is significant that Generation Y is the only one in the

survey that grew up in situation of war and unrest.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

IF conducted the research; LGD analyzed the data; DČ wrote the paper; all authors had approved the final version.

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