Population-Based Emissions Counterfactual

Scope

IAMECON was asked (as a consulting group) to compute the global carbon savings had the UN implemented family planning strategies following global world population conferences.[1]

Accordingly, we designed several counterfactual scenarios to reflect the implementation of these hypothetical strategies. We did not investigate the specific strategies themselves but instead focused on how fast the total fertility rate (TFR) could have been reduced worldwide and the consequences on CO2 emissions.[2] In addition, it is assumed these strategies are non-coercive and are centered around empowering women and girls.

Limitations

This white paper was prepared by Intelligent Analytics and Modeling ("IAMECON")[3], an independent economic research firm based in Austin, Texas, on behalf of its client Carter Dillard.

Facts and findings disclosed in this report are entirely based on the authors' analysis of data and documents, and do not reflect the authors' opinion on the subject matter. The fee received for undertaking this project is in no way dependent upon the conclusions reached in this report and the authors have no financial interest in the project.

Computations:

We understand that there are two major actors contributing to carbon emissions: producers and consumers. Whether as a society we should keep the producers or the consumers accountable for initiating the carbon emissions is outside the scope of this computation. For this exercise, we are asked to approach the problem from the demand side, putting 100% of the responsibility on the consumers rather than producers.

Understanding the demand side of humanity's greenhouse gas emissions can be done through a simple mathematical equation:

$$Population \cdot Per\ capita\ CO_2\ emissions = Total\ CO_2\ emissions$$

The implications are clear. Either the population reduces their average emissions (i.e. the "majority" of people should consume less – but who?[4]) and / or there should be less people emitting via their demand for goods and services. For example, if we wanted to reduce total greenhouse gas emissions by 20%,

[1] More specifically, the 1974 World Population Conference in Bucharest, the 1984 International Conference on Population in Mexico City, and the 1994 International Conference on Population and Development in Cairo.

[2] Roughly, TFR captures the number of children that would be born to a woman across her entire child-bearing years, which is typically considered to be from age 15 to 49. Dr. Chris Tucker, chairman of the American Geographical Society, argues that humanity should reach a global TFR of 1.5 by 2030 in order to secure a sustainable planetary equilibrium. The replacement TFR, agreed to be 2.1, is the rate at which population size remains stable. A TFR of 1.5 means the global population would decline but, as some argue, it is necessary to navigate our planet's current climate and ecological crisis.
See: Tucker, C. (2020). We know how many people the earth can support. *The Journal of Population and Sustainability*, 5(1), 77-85.

[3] www.iamecon.com

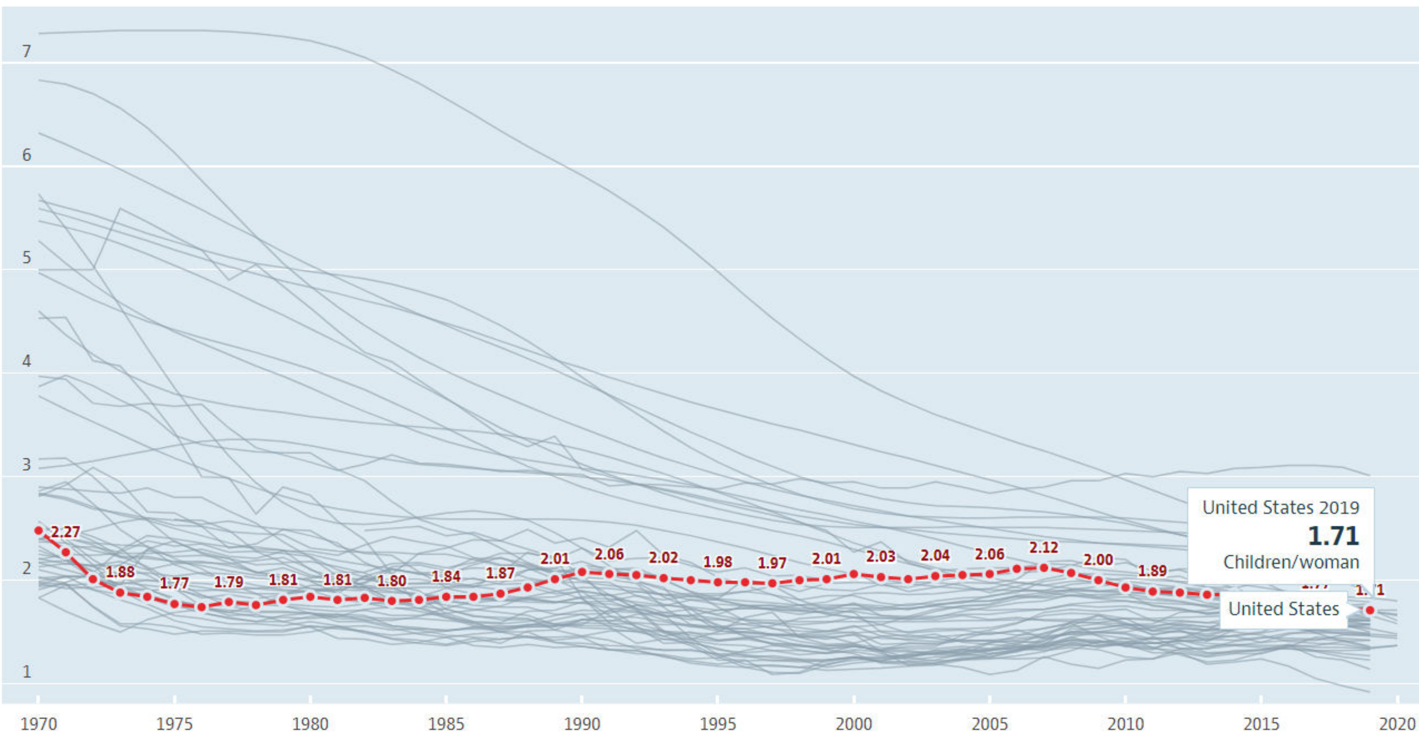
[4] We put "majority" in quotes to emphasize that we do not mean a simple majority, since people can be weighted by their lifestyles and their personal contributions to carbon emissions (i.e., not all people emit equally).

either the total population or the average per capita emissions need to go down by 20%, or a combination that compounds to a total 20% reduction.

There are many amazing studies quantifying and mapping our CO_2 emissions to our consumption habits, from transportation to food choices.[5] In this empirical exercise, we are asked to focus on the population aspect of the equation to compute how much lower CO_2 emissions could have been if certain worldwide family planning strategies had been adopted historically.

It is important to note that many, but not all countries have already achieved this rate worldwide. A time-series depiction of actual TFRs is shown below:[6]

<<Total Fertility Rates by Country, OECD>>



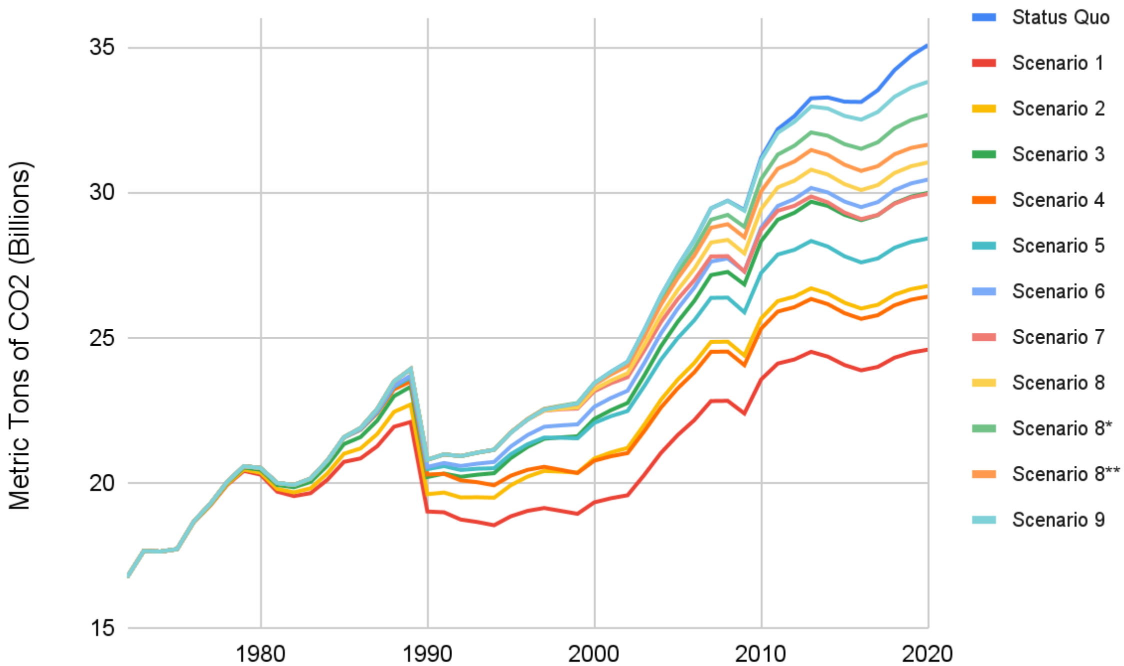
For each of our scenarios below, we compute the estimated carbon savings under the assumption that a family planning strategy would have been implemented at a given assumed year, and achieved the target TFR of 1.5 on a logarithmic convergence path. Note that varying the number of years to achieve the target TFR in each scenario should be interpreted as assumptions of the success of the strategies, and how fast such measures were actually adopted by the residents. Our results are summarized in the following table.

[5] https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator/, https://www3.epa.gov/carbon-footprint-calculator/, https://coolclimate.berkeley.edu/calculator (both accessed March 17, 2022)
[6] https://data.oecd.org/pop/fertility-rates.htm (last accessed March 17, 2022)

Scenario	Implemented	Achieved	2020 Population	Est. Cumulative Carbon Savings (metric tons)
1	1974	1994	5.5B	193.0B
2	1974	2007	6.0B	138.0B
3	1974	2020	6.7B	73.2B
4	1984	1994	5.9B	135.7B
5	1984	2007	6.3B	90.5B
6	1984	2020	6.8B	57.7B
7	1994	2007	6.7B	53.4B
8	1994	2020	6.9B	39.8B
8*	1994	~2023	7.3B	18.8B
8**	1994	2017	7.0B	28.6B
9	2007	2020	7.5B	6.2B
Status Quo	Not implemented		7.8B	0

The figure below shows a time series of carbon emissions for each of the scenarios.

<<Total Global Emissions>>



As is shown, the world would have considerably less carbon in the atmosphere had strategies targeting sustainable TFRs been implemented and achieved within a reasonable amount of time. In the last case, where the strategy was implemented in 2007 as an emergency measure, the change would have still been significant– keeping in mind that the impacts would accumulate well into the future.

To give a standard of comparison, it was estimated that global air transportation in 2018 (including both passengers and freight) emitted 1.04B metric tons of CO_2.[7] The largest savings coming from scenario 1 amount to 193B metric tons of CO_2. Using the 2018 air transportation emission number, the carbon savings from the family planning strategy, which spans 20 years, would have been equivalent to around 186 years of air travel!

Moreover, the International Panel on Climate Change has stated that 670B tons of carbon must be removed from the atmosphere this century. More than likely, we will need to achieve reductions in both per capita emissions (via behavioral change and regulations) and reduce the speed with which the world population grows, to reach the required savings. Although the numbers in our estimate look small in comparison to the required 670B, they are only computed to 2020. Most scenarios would have achieved even more substantial savings by 2100.[8,9]

Methodology

Below is a brief description of our methodology. Please note that these are macro scale computations and many of the complexities have been simplified, such as the measure α that we created and that we explain in the steps below. A more complete counterfactual can be done using agent based simulation models that model various aspects of the strategies in detail, and how individuals respond to such strategies among other things.[10]

1. The total number of children born in a year is found by multiplying the birth rate and the total population for every year.

2. The ratio of fertile female population to total population is calculated by using the female population (divided into 5-year bins) and the total population.[11]

3. We create a measure α that relates the TFR and the fertile female population to the total number of children born in a year.[12] More specifically,

$$\alpha = \frac{Total\ number\ of\ children\ who\ are\ born\ in\ a\ year}{TFR \cdot Population\ of\ fertile\ woman}$$

4. For scenarios 1-8 shown in the earlier table, a logarithmic curve is estimated to reflect a descent of TFR to 1.5 on the achievement dates. For scenario 8*, the same pattern of descent occurring between 1993 and 1994 is extrapolated to the future linearly. Scenario 8** on the other hand, uses the pattern of descent occurring between 1972 and 1973, when the global decline of TFR was strong. Scenario 9 is considered the "emergency measure scenario." This scenario also uses a linear descent of TFR from 2007's actual value to the enforced 1.5 value in 2020.

[7] https://ourworldindata.org/co2-emissions-from-aviation (last accessed March 17, 2022)
[8] Note that we did not run our estimates to 2100 due to the accumulation of error and the difficulty in predicting future population sizes (something not even the UN has done well).
[9] For more information see the following article: Carbon offsets aren't enough. We need to remove carbon from the atmosphere. (last accessed March 17, 2022)
[10] For instance, see https://www.brookings.edu/familyscape/ (last accessed March 17, 2022)
[11] The fertile female population is defined as the number of women who are between 15-49 years old in a year.
[12] This measure is found to be roughly 0.03 over the years. The results are not sensitive to the usage of a constant or varying alpha and the ratio of fertile female population to total population.

5. The following formulas are used to estimate the population growth in each scenario:

$$Total\ \#\ of\ children\ born_t = Fertile\ female\ population_t \cdot TFR \cdot \alpha$$

$$Population_{t+1} = Population_t - Population_t \cdot Death\ Rate_t + Total\ \#\ of\ children\ born_t$$

6. For each scenario, starting in 1972, the projected population for each year is multiplied by the global average per capita carbon emissions. These values are summed, yielding the total carbon emissions. These numbers are then compared with the result of the same computation applied to the status quo scenario.

Data Sources

The data used come from the United Nations and World Bank. The total world population and the age-specific female population is taken from the UN. The birth rate, death rate, total fertility rate and emissions per person are taken from the World Bank. These two institutions are the most reliable sources of these indicators, which are publicly available and can be found online.[13]

An important assumption:

- It is assumed that the yearly death rates, ratio of fertile women, and α for each scenario is the same as in the status quo.

[13] United Nations data: https://population.un.org/wpp/Download/Standard/Population/;
World Bank data:
Birth rate: https://data.worldbank.org/indicator/SP.DYN.CBRT.IN,
Death rate: https://data.worldbank.org/indicator/SP.DYN.CDRT.IN,
Total fertility rate: https://data.worldbank.org/indicator/SP.DYN.TFRT.IN,
Emissions: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC.
(all accessed March 17, 2022)