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**A numerical exercise on climate change
and family planning: World population
might reduce from 11 to 8 billion in 2100
if women of age 15-29 wait and have
their first child at age 30+**

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A numerical exercise on climate change and family planning: World population might reduce from 11 to 8 billion in 2100 if women of age 15-29 wait and have their first child at age 30+

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December 11 2019

Abstract

Family planning could focus on delaying the having of children, instead of (just) reducing the number of children per woman. 66% of all children are born in the mothers' age group of 15-29. A delay of births to the age of 30+ would cause a reduction of the world population by about 0.8 billion in a direct effect. A secondary effect arises when the later born children grow up and have their delay too. There can also be a learning effect. World population might reduce from 11 to 8 billion in 2100. This would cut projected emissions by some 20%. The effect seems important enough to have more research on reasons, causes and consequences of such delay. Strong delay will cause swings in the dependency ratio, which would require economic flexibility, like a rising retirement age from 65 to 70 years. Article 26 of the Universal Declaration of Human Rights of 1948 stipulates the right to education. This right need not be discussed anew. It may be that education does not adequately discuss family planning though.

JEL Journal of Economic Literature codes

P16 Political Economy
J13 Fertility • Family Planning • Child Care • Children • Youth
Q54 Climate • Natural Disasters and Their Management • Global Warming
Q56 Environment and Development • Environment and Trade • Sustainability • Environmental Accounts and Accounting • Environmental Equity • Population Growth
J11 Demographic Trends, Macroeconomic Effects, and Forecasts
E02 Institutions and the Macroeconomy
F55 International Institutional Arrangements
D02 Institutions: Design, Formation, Operations, and Impact
O43 Institutions and Growth
O44 Environment and Growth
Q01 Sustainable Development
E61 Policy Objectives • Policy Designs and Consistency • Policy Coordination
H23 Externalities • Redistributive Effects • Environmental Taxes and Subsidies
I30 Welfare, Well-Being, and Poverty – General
O11 Macroeconomic Analyses of Economic Development
A10 General Economics - General

Keywords: family planning, fertility, birth delay, climate change, population, carbon tax, fertility tax, political economy

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1. Introduction

1.1. The main idea of this report

This report is a numerical exercise to explore the magnitude of the possible effect of a delay by mothers, to wait till the age of 30+ before giving birth to their first child.

(1) There is no infringement on the reproductive rights of women. Potential mothers in the age group 15-29 years merely delay having their first child to when they are 30 years or older.

(2) Currently 66% of all children are born in the mothers' age group of 15-29. A delay to 30+ would amount to a reduction of the world population by about 0.8 billion in a direct effect, see **Table 1**. A secondary effect arises when the later born children grow up and have their delay too. There can also be a learning effect.

(3) A roughly indicated effect is: World population might reduce from 11 to 8 billion in 2100 if women of age 15-29 wait with having their children and have their first child at age 30 or higher. This would cut projected annual CO2-equivalent emissions by some 20 - 25% in 2100. While a "business as usual" (BAU) scenario has a temperature rise of 4.5° Celsius in 2100, this might drop to 3.8° Celsius merely because of this delay.

Table 1. Assumptions on (cumulative) delay

Age of Mother	Births 2015-2019	Births 2020-2024	Births 2025-2029	Births 2030-2034	Births 2035-2039	Births 2040-2044
15-19	62 366					
20-24	195 007					
25-29	207 342					
30-34	142 213	142 213	142 213 + 207 342	142 213 + 207 342 + 195 007	142 213 + 207 342 + 195 007 + 62 366	606 928
35-39	68 372	68 372	68 372	68 372	68 372	68 372
40-44	21 576	21 576	21 576	21 576	21 576	21 576
45-49	4 401	4 401	4 401	4 401	4 401	4 401
Sum	701 277	236 562	443 904	638 911	701 277	701 277
Delay+		464715	722088	784454	784454	784454

PM. This table used fixed birth numbers for didactics. In the excel sheet, the delayed births are translated in birthrates and applied to the relevant age groups, giving different numbers.

I am merely an econometrician, and no demographer or medical doctor or family planner. I am only curious whether the magnitude of the effect might make it relevant to ask demographers and medical doctors and family planners to look into the following scheme. Family planning could focus on delaying the having of children, instead of (just) reducing the number of children per woman.

1.2. A key report that cannot deal with this effect

Gerlagh, Lupi & Galeotti (2018) take the age group 15-45 as a single generation (unit), so that they cannot simulate this (intra-unit) effect. They consider the external effects of births that must be taxed (a fertility tax), instead of ways to *avoid* the problem and such tax. They reduce population by having less children instead of later, and thus they directly engage the issue of

reproduction rights. However, it seems that their model might be adapted easily to include this effect of delay. They obviously agree that population is a key variable, see their abstract:

“The historical increase in emissions is for one-fourth attributable to the growth of emissions per person, whereas three-fourths are due to population growth. This striking evidence is not represented in the majority of climate-economic studies, which mostly neglect the environmental consequences of individuals’ reproductive decisions. In this paper, we study the interactions between climate change and population dynamics. We develop an analytical model of endogenous fertility and embed it in a calibrated climate-economy model. Our results present family planning as an integral part of climate policies and quantify the costs of neglecting the interaction.”

1.3. On the road to a 3.2°C rise by 2100 ?

The UN Climate Change Conference COP 25 (2 – 13 December 2019), ¹ in progress when writing this, refers to a new UNEP report: ²

“On the eve of a year in which nations are due to strengthen their Paris climate pledges, a new UN Environment Programme (UNEP) report warns that unless global greenhouse gas emissions fall by 7.6 per cent each year between 2020 and 2030, the world will miss the opportunity to get on track towards the 1.5°C temperature goal of the Paris Agreement.

UNEP’s annual *Emissions Gap Report* says that even if all current unconditional commitments under the Paris Agreement are implemented, temperatures are expected to rise by 3.2°C, bringing even wider-ranging and more destructive climate impacts. Collective ambition must increase more than fivefold over current levels to deliver the cuts needed over the next decade for the 1.5°C goal.”

While COP 25 and UNEP tend to look at conventional measures like the carbon tax (which is advisable indeed), it seems unavoidable that we also consider population and family planning.

An annual reduction of 7.6% for 10 years means a total reduction of 55% (leaving 45%). The current 2019 annual emissions of 55 Gt thus must be reduced to 25 Gt. ³ By coincidence, the “commitment” for reduction in 2030 is 56 Gt, and the additional effort to reduce this to 25 Gt has the same target reduction size. However, in the BAU scenario, emissions rise to 61 Gt in 2030, and the effect of delayed births in this period means a reduction to 56 Gt, or a reduction of 8%. Compared to BAU, the delay contributes only 1 year in the period 2020-2030 for said target of 7.6% per year in the next decade.

The 20 - 25% overall reduction identified here for 2100 covers some 4 years of the COP25 call for 7.6% reduction each year between 2020-2030, but this effect arises much later.

1.4. A numerical exercise

The properties of *delaying births* must be in basic textbooks on demography but I did not see it discussed in some references that I found when searching on family planning and climate change. Roser (2014, 2019) at Oxford ⁴ has data on fertility per level of education, but education *at any level* might call attention to the relevance of delaying births to a higher age.

The present exercise is only a numerical one, and performed to gauge the magnitude of the effect of delay. We use aggregate data on the current world population. The only result of this paper and its numerical exercise consists of this calling attention to the potential relevance of this *delaying of births*. The effect seems important enough to have more research on reasons, causes and consequences of such delay.

¹ <https://unfccc.int/cop25>

² <https://unfccc.int/news/cut-global-emissions-by-76-percent-every-year-for-next-decade-to-meet-15degc-paris-target-un-report>

³ <https://www.unenvironment.org/interactive/emissions-gap-report/2019/>

⁴ <https://ourworldindata.org/future-population-growth>

The relation between population, emissions, ppm and temperature is complex.⁵ For the present exercise, we may take some key results from official simulations and use simple interpolation for the (proportional) effects of small differences.

Article 26 of the Universal Declaration of Human Rights⁶ of 1948 already stipulates the Right to Education. Thus it is not a point of discussion whether education is needed. The present discussion may however indicate some urgency in education, in particular concerning family planning. The focus might be on delaying having children, and not on lower fertility on itself.

The indicated magnitude warrants the conclusion that more research on delaying births would be interesting. Not to establish whether this road might be taken, since education already is a human right, but to explore the details that can be communicated in education on family planning. For the children that will be born this century, it would seem to be advisable to provide children with an environment that is not burdened with climate change and other environmental damages, see Huetting & De Boer (2019) and Colignatus (2019).

2. Main finding

Family planning involves both delay and avoiding unwanted children. The following has three scenario's:

- (0) a baseline, with a world population of 12.5 billion in the year 2100 (almost UN "medium")
- (1) delay births, while maintaining the same birth numbers, ending in 9.3 billion in 2100
- (2) delay, and 80% lower birth numbers because of a learning effect,⁷ ending in 7.5 billion.

The data have been taken from the UN Population Division, and are reproduced in **Table 2** in **Appendix A** and the separate excel workbook. This is a rough exercise: (a) birth and mortality data are cross-sectional and not longitudinal, (b) five-year age groups, (c) world data only. The official medium UN projection has 11.2 billion in 2100, and my baseline outcome of 12.5 billion is not far out of range. The uncertainties remain large and this is an indicative exercise only. **Table 3** in **Appendix B** gives current data about expectations about scenario's for 2100.

Table 1 shows how births can be delayed, and cumulate to 0.8 billion in a direct effect. This table shows the levels of 2015-2019 while the scenario's use birth rates.

Notwithstanding the uncertainties, the conclusion seems warranted that the effect might be a reduction from 11 billion to 8 billion people in 2100. It would cut projected emissions by some 20-25%. **Figure 1** shows the population sizes for the three scenario's to 2100.

Figure 2 shows the dependency ratio's, with the active age group 15-64 in the denominator and the other age groups in the numerator. The ratio first drops to 40% and rises to 80% for a while. When the reduction in the population size comes along with improvements in economic conditions, then a rise in the retirement age might be possible from 65 to 70, reducing the number of dependents and increasing the denominator.

A scenario with delay requires economic flexibility anyway. Schools might be rather vacant for 15 years. In the first five years the number of children drops to 34% of the current figure, and over 15 years it only gradually rises to (almost) 100% again.

Women in the richer countries with more emissions per person already have their children at a later age. In the present rough exercise, the delay of having children would disproportionately affect women in countries with less emissions per capita. The excel sheet that uses the world data indicates a reduction of emissions by 25% in 2100, but this likely overstates the effect, and it is more likely that the reduction would be 20%.

⁵ <http://www.darkoptimism.org/2008/09/03/climate-science-translation-guide/>

⁶ <https://www.un.org/en/universal-declaration-human-rights/>

⁷ There is also the proverb "another time may be too late" (Dutch "van uitstel komt afstel" meaning "from delay comes cancellation")

Figure 1

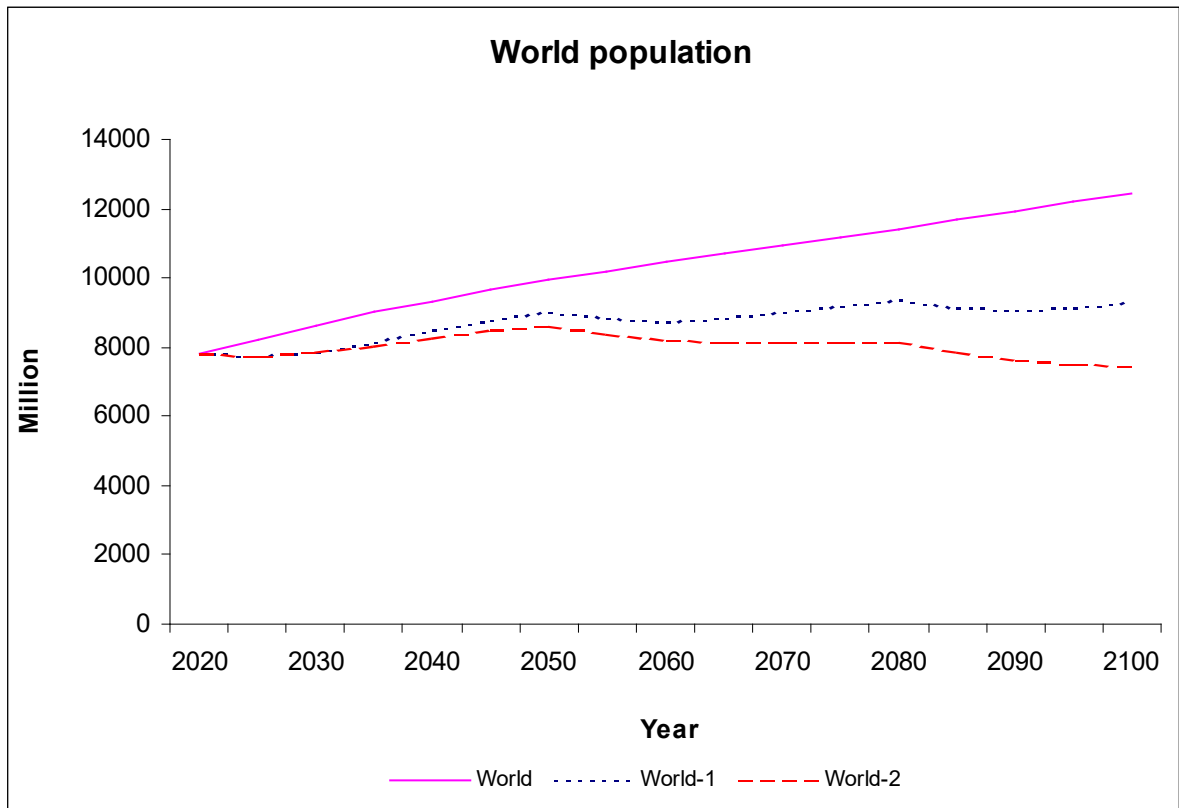
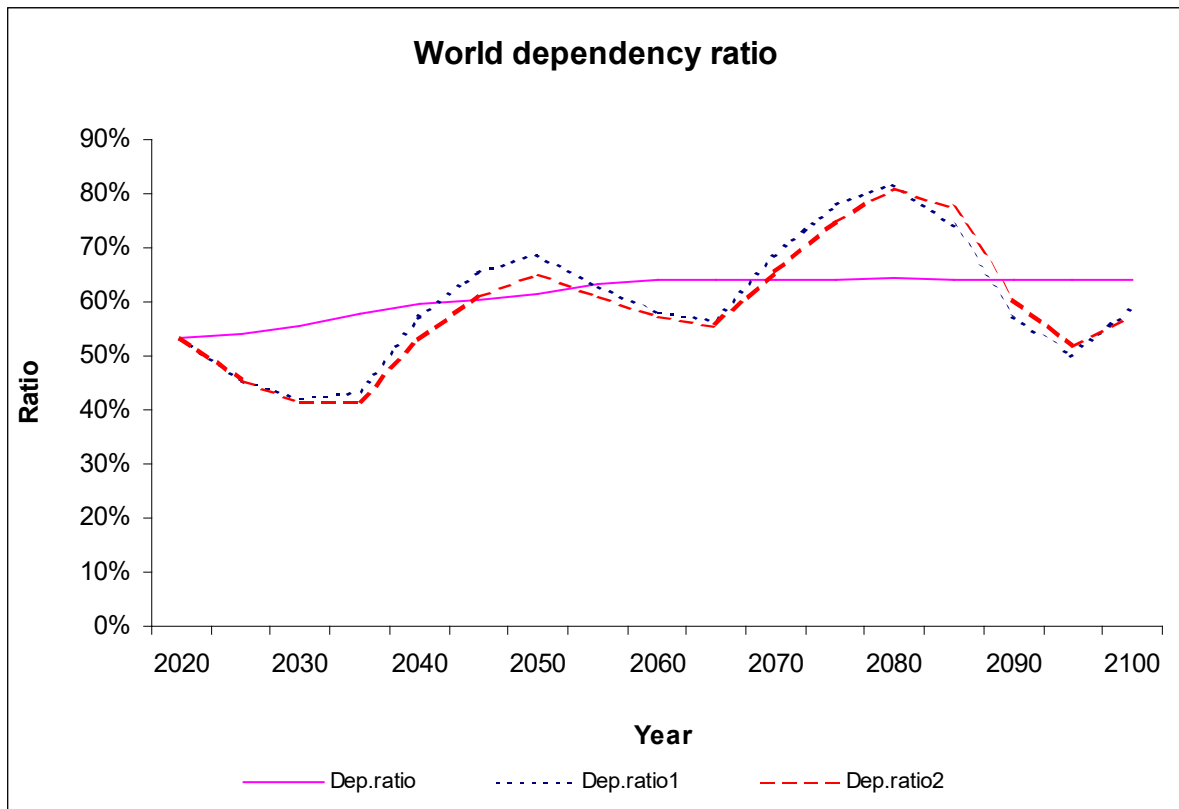


Figure 2



3. Discussion

The outcome is somewhat paradoxical: basically fertility, or the number of children per woman, does not change, but there still is such a large effect at 2100. I can only assume that this result derives from the long delays in the human life cycle and replacement rate.

Obviously, there are already Family Planning 2020 (FP2020)⁸ and other organisations looking at family planning.

The impact of population is rather obvious with the equation $I = P A T$, with I = the impact (emissions of CO₂), P = population, A = affluence (GDP / P), and T = technology (CO₂ / GDP).

O'Neill et al. (2012) suggest that emissions are rather proportional to population anyway. O'Neill et al. (2012) review the literature on the role of population, but not yet quite on the effect discussed here. Their abstract:

“Relations between demographic change and emissions of the major greenhouse gas carbon dioxide (CO₂) have been studied from different perspectives, but most projections of future emissions only partly take demographic influences into account. We review two types of evidence for how CO₂ emissions from the use of fossil fuels are affected by demographic factors such as population growth or decline, ageing, urbanisation, and changes in household size. First, empirical analyses of historical trends tend to show that CO₂ emissions from energy use respond almost proportionately to changes in population size and that ageing and urbanisation have less than proportional but statistically significant effects. Second, scenario analyses show that alternative population growth paths could have substantial effects on global emissions of CO₂ several decades from now, and that ageing and urbanisation can have important effects in particular world regions. These results imply that policies that slow population growth would probably also have climate-related benefits.”

For biological optimality for mother and child, the best age for the mother might be 25 years. It would already be an important step if the age group of 15-24 years delays to 25+. However, climate change creates a formidable challenge. The 30+ target is relevant.

Colignatus (2004) develops the idea how a registry on HIV and oncogenic HPV might support healthy behaviour. Such registry and behaviour might well extend on fertility. Carrots might tend to work better than sticks (“fertility tax”). Women and their families might be encouraged to delay births by financial rewards and by support from potential medical treatments that would be developed for this purpose. Obviously such methods must be designed with care. An example of fraud might be that an older woman claims the child of a younger woman (sister) as her own child. A young woman who enters a registry and / or financial scheme however might accept the consequence that there could be a semi-annual checkup.

The social status of a young woman tends to rise when she has become a mother. It would require serious social engineering to link such status to other (responsible) behaviour. Potentially a part involvement with raising children (of others) would remain important.

Women in the age group 15-29 have a mortality of 2% (world average). The delay would come with 2% of 66% = 1.32 % lower births in total. Part of the mortality may be related to death at childbirth though. In the present calculation the 66% part is delayed without looking at mortality. (PM. When women in this age group have no children and come to pass away, then their parents will lose an unborn grandchild too. One might offer egg-cell storage but this would not replace the lost mother. Grand schemes at the macro level cannot deal with all the moral and personal issues at the micro level.)

These studies indicate that policy makers and researchers are reluctant to directly tackle population. There is a discussion in the media that may be mentioned too. Alexander & Carter (2019) commemorate Hans Rosling (1948-2017) on statistics on health and population, and

⁸ <https://www.familyplanning2020.org/about-us>

discuss demography for BBC.^{9 10} Rosling suggested that Africa is now where China was around 1900, which may be true demographically, but which causes a lot of questions about history and culture and other drivers of population growth. Rosling made the point that less population can mean higher income and then a greater burden on the environment. We indeed require integrated assessment modeling, going beyond the present numerical exercise. Rosling might not have considered a delay in births:

“But there's an old vision of over-population and population causing disastrous environmental effects. If we look into the middle of this century, and if Africa makes it - stability, economic growth, social progress, rights for women, stable government, they get two child families - then they will be a burden on the environment.”

Writing on this topic, I had some personal commemorations too, see **Appendix C**.

4. An issue of political economy

Notwithstanding the role of demographers and medical doctors and family planners, there still seems to be a role for political economy for this issue. I do not want to argue that economists per se have a role here, but such a role would be important and advisable under conditions that warrant that economics is used in scientific manner. Colignatus (2000, 2011) (2014) discuss the failure of the Trias Politica model of the checks and balances in current models of democracy. It is advisable that each nation installs an Economic Supreme Court with a foundation in economic science. Unemployment and poverty are basically caused by the current failure of the Trias Politica model of democracy. It is important to keep this in mind when also considering this present issue.

5. Conclusion

This paper has done a numerical exercise only. The magnitude of the observed effect warrants the conclusion that more research on delaying births would be interesting.

⁹ <https://www.bbc.co.uk/sounds/play/p04w85zn>

¹⁰ <https://www.gapminder.org/>

6. Appendix A. The demographic data used

Table 2. World population 2020 by age and sex, births and mortality

Age	F + M 2020	Female 2020	Male 2020	Births ¹¹ 2015-2019	Deaths F 2015-2019	Deaths M 2015-2019
0-4	677 942	328 509	349 433		12 554	14 953
5-9	664 439	321 512	342 928		1 606	1 839
10-14	641 267	309 770	331 497		1 021	1 229
15-19	612 196	295 554	316 642	62 366	1 400	1 953
20-24	597 388	289 101	308 287	195 007	1 691	2 644
25-29	594 692	288 633	306 059	207 342	1 867	2 892
30-34	605 531	296 294	309 237	142 213	2 078	3 286
35-39	544 819	268 372	276 447	68 372	2 358	3 785
40-44	493 789	244 399	249 390	21 576	2 802	4 434
45-49	479 366	238 133	241 233	4 401	3 492	5 714
50-54	445 773	223 163	222 610		4 881	7 643
55-59	387 849	195 634	192 215		6 207	9 991
60-64	322 142	164 961	157 180		8 527	12 754
65-69	269 644	140 704	128 939		10 735	15 059
70-74	188 677	101 491	87 186		12 748	16 228
75-79	123 782	69 027	54 755		14 876	16 892
80-84	81 930	48 281	33 649		16 423	15 181
85-89	42 186	26 429	15 757		14 212	10 659
90-94	16 680	11 352	5 328		8 939	5 016
95-99	4 134	3 056	1 078		3 692	1 439
100+	573	449	124		449	124
Sum	7 794 799	3 864 824	3 929 974	701 277		

Source: © 2019 by United Nations, made available under a Creative Commons license CC BY 3.0 IGO: <http://creativecommons.org/licenses/by/3.0/igo/>

Citation: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, custom data acquired via website.

¹¹ Births are recorded by the age of the mother.

7. Appendix B. Key data on climate change

Not only the climate changes, but also the information about it. There are ever newer insights and developments. It is useful to record what the situation is at the moment of writing this memo.

Table 3. Key data in 2019 on climate change

<i>Scenario / Data</i>	<i>Temperature Rise (2100)</i>	<i>ppm CO2 (2100)</i>	<i>ppm CO2eq (2100)</i>	<i>Annual CO2eq Emissions (Gt) (2100)</i>
<i>Confirmed Proposals As 2011-03-01</i>	4.0°C	800	1060	103.40
<i>NDCs Strict As of 2015-12-14</i>	3.5°C	670	855	81.33
<i>2°C Pathway As of 2015-10-27</i>	2.0°C	475	485	6.01
<i>1.8°C Pathway As of 2015-12-14</i>	1.8°C	450	455	2.93
<i>1.5°C Pathway As of 2015-12-14</i>	1.5°C	425	420	0.92
<i>2014 'Actuals'</i>	0.9°C	397	481	54.96

Source: Climate Interactive Scoreboard, Based on climate action pledges of UN member countries, NOAA-ESRL, <https://www.co2.earth/2100-projections> [retrieved today]

8. Appendix C. Commemoration

Writing on this subject, I want to commemorate my great-aunt Petronella (Nellie) Gerarda Maria Diels (1904-2000). On 1933-10-27 she became Sister Jacques-Marie (commemorating her parents) of the Missionary Sisters of Our Lady of Africa, a.k.a. the White Sisters.¹² She devoted herself to teaching, like her father had (i.e. my great-grandfather on my mother's side). She taught girls in Sumve, Mwanza, Tanzania, and later trained teachers there. A cornerstone of her teaching was that people should think for themselves. One of her pupils was Maria Magige who later married Julius Nyerere ("Mwalimu" - teacher) who later became Tanzania's president. **Figure 3** is a picture from 1971 when sr. Jacques-Marie retired at age 67. When retired in Holland, she made a return visit around 1980 and met with her pupils, now teachers, see **Figure 4**. Economists often seem to forget that education is also a national investment.

Figure 3. Visit by president Nyerere (third from top left) at the school in Sumve in 1971 at the retirement of sister Jacques-Marie (fourth from top left). Fifth from top left is Maria Nyerere, the president's wife, and a pupil of sister Jacques-Marie

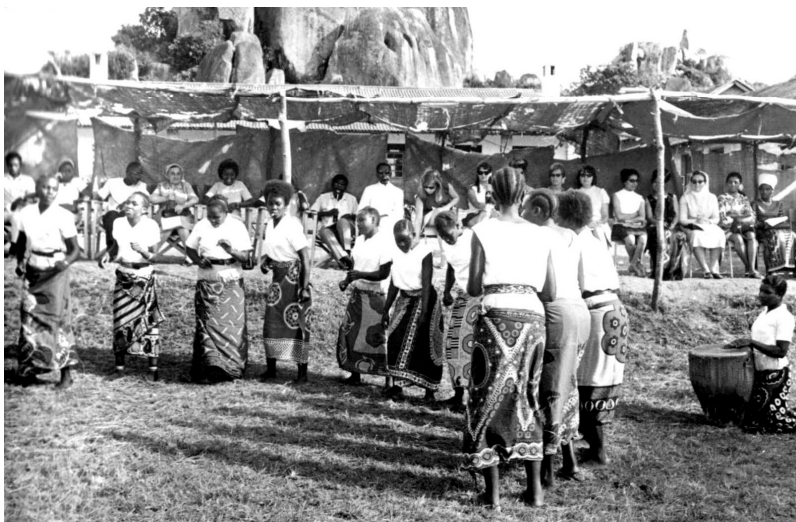


Figure 4. State House, Dar es Salaam around 1980, sr. Jacques-Marie visiting with her former pupils, now teachers



¹² https://en.wikipedia.org/wiki/Missionary_Sisters_of_Our_Lady_of_Africa

I also want to commemorate Louis Emmerij (1934-2019).¹³ He was one of my first contacts in writing about development, see Cool (1981) (in Dutch), and I very much appreciated his response back then, though I did not convince him back then: that a basic needs strategy would be most advisable, both morally and, if that would matter, economically. I would suggest that education is a basic need too. For example, for the present topic of discussion, one would opt for good education anyhow, and it would seem to be a minor point of educational insight that one would also discuss the properties of delaying births to age 30 or higher. The presently discussed path would already been taken, and demography and economics only come in to establish some details.

9. References

Colignatus is the science name of Thomas Cool, econometrician (Groningen 1982) and teacher of mathematics (Leiden 2008), Scheveningen.

This paper uses an excel sheet <http://thomascool.eu/Papers/Environment/2019-12-11-Numerical-demography-final.xls>

Not all footnotes are listed in these references.

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¹³ <https://www.iss.nl/en/news/passing-away-professor-louis-emmerij>