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How many people on earth? World population 1800 1938 [1]

The number of people is one of the most basic information about any society but we hardly know it until the early 20th century. The easily accessible sources refer to few advanced countries and thus widely used data-bases build series for other countries with interpolations. In this paper we fill this gap by re-estimating series of population for all existing polities from 1800 to 1938 using first-hand sources and the country-specific literature. We are thus able to date, albeit tentatively, the start of the demographic transition in data-scarce peripheral countries and to measure the impact of major demographic crises such as the Tai'ping civil war, World War One and the Spanish flu.

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1. Introduction: why it is important

The number of people is one of the most basic information about any society and it is essential for debates on three issues are now attracting much interest among economic historians and economists such as the demographic transition, the role of market integration in reducing the impact of agricultural production failures and the effect of pandemics.

The conventional wisdom argues that market integration and economic growth reduced the size of demographic shocks in the 19th and early 20th century. The former reduced impact of crop failures (e.g. O' Grada and Chevet 2002, Burgess and Donaldson 2011), while economic growth improved nutrition and health conditions. It made it possible to invest in provision of clean waters and sanitation, which greatly helped to fight waterborne diseases, including cholera (Haines 2000, Chapman 2019, Chaudhary and Lindert 2021). Spanish flu was an exception for its aerial transmission, which caused a world-wide impact and a huge death toll (Beach et al 2021). The demographic transition has long been studied by demographers and economic historians (Chesnais 1992, Kirby 1996, Lee 2003, Alter and Clark 2010, Davenport and Saito 2021, Perrin forthcoming) but it has enjoyed a revival of interest among economist (Guinnaine 2011), because it features prominently in unified growth theory models. Scholars have explored the patterns of transition (Delventhal et al 2021) and analyzed the causes of decline in fertility (cf e.g. Murtin 2013) and the relations between long-term life expectancy and GDP change (cf. e.g. Cervellati and Sunde 2011)

These works are based on very partial and often defective evidence. Before 1950 series of population and above all vital statistics are available only for a handful of advanced countries. For instance Murtin (2013) use a for a balanced sample of 16 advanced countries from 1870 to 2000. The book by Chesnais (1992) on demographic transition covers the whole world, but its information on the periphery is absent or very

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sketchy and he advocates using population trends as a proxy. The deaths from Spanish flu are estimated with a mix of actual data, guesstimates by experts and econometric estimate of excess deaths. Thus, the number of covered countries and the results differ rather widely, from 17-24 million (Spreeunwenberg et al 2018) to 35-44 million deaths (Athukorala and Athukorala 2020), with unsubstantiated guesses up to 100 million[2]. Also world-wide long-term trends are poorly measured. Historical demographers have made substantial efforts to produce country-specific series but their results have seldom trickled down in world-wide data-bases. The most commonly used data-sets are based on partial and outdated scholarship (McEvedy-Jones 1978, Maddison 1995) or, as Gapminder, they rely on hardly transparent interpolations from these same historical data-sets. Yet, these data are being widely used in econometric analysis (Guinnaine 2021).

This paper aims at filling this gap. We estimate series of population at current borders for all polities from 1800 to 1938, and then we sum them to get the continent and world total(s). When possible, we use official statistics, but in most cases we rely on the work by demographic historians who have painstakingly collected and, when necessary corrected, official data and any available information. We fill gaps with interpolations or extrapolations, taking into account whenever possible the population movement in neighboring or otherwise comparable polities. Needless to say, our figures are of widely different quality, ranging from the almost perfect for Scandinavian countries to the mere guesswork for Sub-Saharian Africa. The amount of guesswork is the greater the less capable the administration was, and thus as a rule earlier data are less reliable than more recent ones. Most of the figures of the first half of the 19th century are highly conjectural and there are almost no data on the 18th century.

The next section surveys the estimates of world population, Section Three discusses in general our sources and Section Four sketches out our strategy of estimation, with details by polity in Appendix I. Section Five outlines long-term population trends results and compare them with previous estimates. In a nutshell, world population has been growing with underlying faster rate, as more and more countries entered the demographic transition but the overall growth was substantially slowed down by two major exogenous shocks (plus minor local ones), the Tai'Ping civil war in China in the 1850s-early 1860s and the late 1910s world crisis (the combination of World War One, Spanish flu and Russian civil war and famine). Section Six tests the conventional wisdom about the decline in volatility and analyses the frequency and severity of demographic crises. Section Seven deals with the demographic transition, focusing on the periphery. Section Eight explores the robustness of our series. We estimate the likely margins of errors of the aggregate series, on the basis of our assessment of the quality of individual polity ones and we discuss the biases for the analysis of volatility from linear interpolation and for the dating of the demographic transition from the omission of migration flows (with a much expanded data-set on natural increase of population). on the conclusions about population volatility and demographic transition. Section Nine concludes with some ideas for further research.

2) What do we (pretend to) know

[2] This figure, which is often quoted in the historical literature, is a speculative guess by Johnson and Mueller (2002). The sum of their country estimates yield a total of 33-43 million, but they increase it to 50 million, and add that even this figure 'may be substantially lower than the real toll, perhaps as much as 100% understated' (p.115)..

In 1661, the Italian Jesuit Riccioli put forward the first known estimate of world population at 'less than one billion' (Korenjak 2018) and since then many scholars have followed his example. The American demographer Willcox (1940) lists 68 benchmark estimates of world population plus an almost yearly series from 1851 to 1927 in the various editions of Hubner's Geographical Atlas. Willcox was one the pioneers of modern work on the issue, jointly with Carr-Saunders (1936), and these two authors have been highly influential in all the following literature (Caldwell and Schindlmayr 2002). A possibly incomplete list includes about thirty estimates for world population in the 19th and 20th centuries since the 1930s but quite a few of them simply reproduce figures from some other authors (see for an analysis of these derivations Appendix ?). Thus, in Table 1 we report only the 'original' estimates, which feature relevant changes in figures by continent and (hence) for the world population.

Table 1
Estimates of world population

	1800	1820	1850	1870	1890	1900	1910	1913	1920	1930	1935	1940	1950
Hubner*			1055a	1300	1514	1551	1568	1652	1712	2029b			
Willcox (1940)	919		1091			1571					1995		
Carr-Saunders (1936)	906		1171			1608					2057c		
Swaroop (1951)	906					1171							2378d
Bennett (1954)	919		1163			1555							2368d
Clark (1967)	890					1668							
McEvedy and Jones (1978)	900		1200			1625							2500
Biraben (1979)	954		1241			1633							2520
Klein Goldewijk and Battjes (1995)					1532	1638	1767		1914	2084		2281	2511
League of Nations/UN									1834	2008		2216	2532
UN 1999	980		1260			1650	1750		1860	2070		2300	2520
Maddison (2010)		1042		1276		1563		1792	1863			2299	2528
HYDE 3.1	990		1263			1654	1777		1912	2092		2307	2545

*quoted by Willcox (1940); a 1951;b 1929; c 1933; d 1949

All estimates tell a similar story, with an accelerating growth throughout the period, but differences between them are substantial, especially in the first half of the 19th century and for poor countries. The worldwide rates of growth for the 19th century range from 0.51% (Klein Goldewijk et al 2010) to 0.63% (Swaroop 1951) – a difference by almost a quarter. The highest rate for Africa, 0.50% (Klein Goldewijk et al 2010) is 3.4 time larger than minimum one, 0.11% (Clark 1967). The maximum/minimum ratio is 1.67 for Asia, 1.43 for America (presumably as sum of a very low difference North and a large one in the South) and only 1.20 for Europe. In the first half of the 20th century, the differences are decidedly small for the world (rates between 0.80% and 0.85%) but still substantial for some continents, especially Africa[3].

Only five estimates report yearly data by polity, and not all of them quote their sources in any detail. The Statistical Yearbook of the League of Nations, the forerunner of the current UN population data (United Nations), published figures for 1913 and series from 1922 to 1938, supplementing the available official data with crude estimates for missing countries. McEvedy and Jones (1978) plot graphs for some major countries and macro-areas since 1 AD, adding figures for benchmark years (in the period of interest 1800, 1850 and 1900). The Maddison project website reports the original estimates by A. Maddison of world population in the 1990s as a by-product of his well-known reconstruction of historical GDP series. He collected the (then) available data and integrated them with benchmark guess-estimates for many other polities. His data base features a growing number of population series by polity (Figure 1 blue bars, left axis) from about 20 before 1870 to 60 on the eve of World War Two, which accounted for three quarters of world population according to Maddison's own estimate (red line, right axis) for most of the period, with an increase to about 85% in the 1930s[4]

[3] The ratio between maximum and minimum figures range from 1.14 for Asia to 1.83 for Africa – in the latter case between 0.68% (Swaroop 1951) and 1.25% (Mc Evedy Jones 1978). Our computation excludes the two estimates by Willcox (1940) and Carr-Saunders (1936), which refer to 1935. Including them the difference among rates of growth would be much larger.

[4] Here we use Maddison's original data-set, as detailed in Maddison 1995 and 2010. The most recent version of the Maddison project website reports the country data for three benchmarks only (1820, 1870 and 1913). The number of series is bound to differ between Maddison's and our data-base because the former is at current and the latter at 1995 borders and because Maddison reports aggregate data for groups of small polities (e.g. 21 Caribbean). We compute Maddison's yearly series of world population (the denominator of the ratio in Figure 1) by interpolating linearly his figures for 1820, 1870, 1913 and 1940.

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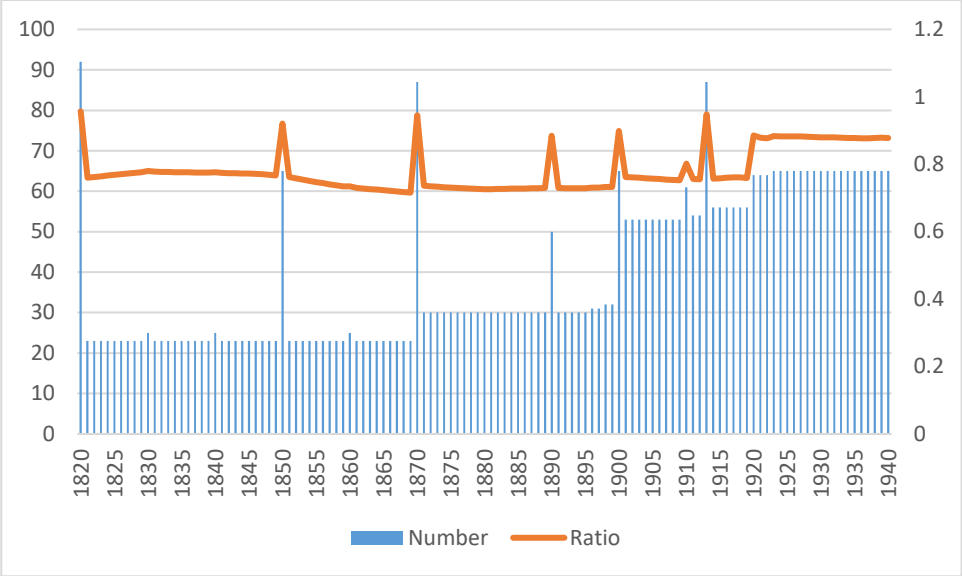
Figure 1

Maddison's world population data-base



Last but not least, two on-line data-bases publish data by polity: the environmental data-base HYDE 3.1 (Klein Goldewijk et al 2010) reports data at ten-year intervals since 8000 years BC for 237 polities and the Gapminder (https://www.gapminder.org/data/, accessed July 2021) yearly series for 197 polities from 1800 onwards [5]. The origin of these data is mysterious: data-bases quote general sources such as Maddison, without any detail on their methods of estimation [6].

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[5] Other sources, including statistical yearbooks of European states (e.g. Annuaire Statistique Francaise Statistiches Jahrbuch, Board of Trade). and other contemporary statistical collections (e.g. the Statesman's yearbook) collect but do not sum them in a world total. Etemad (2007 Appendix D) provides figures for all colonies in 1760, 1830, 1880, 1913 and 1938 without detailing his sources. The CLIO-Infra project (Van Vleuten and Kok (2014), as reported in its website (https://clio-infra.eu/Indicators/TotalPopulation.html; accessed Sept 5 2021), lists several standard sources (Maddison 1995 and 2010, McEvedy-Jones 1978, Mitchell 2007, Kuczynski 1948-1949 and so on) without any further detail on how these have been used or how gaps have been filled.

[6] The HYDE 3.1 writes in the source file 'Historical population numbers of McEvedy and Jones (1978), Livi-Bacci (2007), and Maddison (2003), Denevan (1992) form the basis of our national historical population estimates. Supplemented with the sub-national population numbers of Populstat (Lahmeyer, 2004, pers. comm.; who provides data for several time periods varying per country), time series were constructed for each province or state of every country of the world'. An earlier version of the same HYDE data-base (Klein Goldewijk et al 1995) used a transparent, albeit highly questionable, statistical interpolation method. They assume a logistic curve between the earliest available data from Mitchell's International Historical statistics and the start of United Nations population series in 1950, with some adjustments. Gapminder v6 states in its explicative note (https://www.gapminder.org/data/documentation/gd003/ - accessed 5 Sept 2021) 'We use Maddison population data improved by CLIO INFRA in April 2015 and Gapminder v3 documented in greater detail by Mattias Lindgren. The main source of v3 was Angus Maddison's data which is maintained and improved by CLIO Infra Project. The updated Maddison data by CLIO INFRA were based on the following improvements: i. Whenever estimates by Maddison were available, his figures are being followed in favor of estimates by Gapminder; ii. For Africa, estimates by Frankema and Jerven (2014) for the period 1850-1960 have been added to the existing database; – For Latin America, estimates by Abad and Van Zanden (2014) for the period 1500-1940 have been added'. In all fairness, it is to be added that Gapmider does not claim any historical accuracy. In their

3) Our sources

Knowing the number of their subjects, as potential taxpayers and/or soldiers, has always been a major concern for rulers and governments since the early antiquity. The first counts of population may date back 4000 years BC Babylonia and all great empire, including Rome and China, followed suit. The first 'modern' censuses, with detailed information for all individuals, were taken in the early 19th century (Shryock et al 1971, Thorvaldsen 2018). In 1855-1864 only 24 sovereign countries had taken a census, and the number rose to 49 in 1925-1934 (Shryock et al 1971 tab 2.1), plus 18 colonies (Kuczynski 1937). The number jumped to 150 in 1955-1964, after the strong prodding by the United Nations. By definition, censuses are snapshots: a full reconstruction of movements of population needs yearly data, which can be kept only by registering the number of birth, deaths and migrations. In Europe, the Catholic local clergy started to collect these data in the Middle Ages (the earliest surviving French register dates back to 1303). In the 16th century the compilation of these registers was made compulsory by several states (e.g. England in 1538, France in 1539) and by the Catholic church with the Council of Trento (1563/1614). Following the pioneering work by Henry, historical demographers have used parish registers to produce series of local population. Wrigley and Schofield (1989) have used 404 such registers to produce their monumental *Population history of England* and they have been imitated by scholars for other countries, such as Northern Italy (Galloway 1994) and Germany (Pfister and Fertig 2010). Unfortunately, there is no guarantee that the surviving registers yield a representative sample of parishes (Spagnoli 1977). In the 18th century some European states started to collect parish data and in the early 19th century they set up centralized population registers (Wilke 2004, Poulain and Herm 2013).

There is no need to dwell further on the historical evolution of demographic sources. It is however important to stress that in the 19th and early 20th century the ideal combination of modern censuses and accurate centralized population registers can be found in few, mostly advanced, countries. For instance, China had a state registration system with no fiscal purposes, the bao-jia system, since 1741 (Ho 1959:36-50 and 68-73), but not a proper census until 1953. Demographic sources are problematic also in some advanced countries. A national register of birth and death was set up in ten American states only as late as 1900, and was extended to the whole country only in 1933 (Haines 2000). Furthermore, the censuses of the 19th and early 20th century undercounted population, up to 10-15% according to some local tests (Coale and Zelnick 1963, Coale and Rives 1973, Shryock et al 1971, Parkinson 1991, Steckel 1991 Thorvaldsen 2018 pp.98-). Unfortunately, so far, no scholar has put forward a corrected series for the whole period and the Population Section of the Millennial version of the Historical Statistics US (2006) mostly reproduces the official data.

The shortcomings of censuses is, unsurprisingly, more serious for poor countries and colonies, especially for large mainland territories, while counting people was easier in small islands[7]. Much depended on the

website they state that 'our data is more consistent over time and space than most other sources, because we dare to fill all the gaps in the sources. We dare this because our purpose is to show people the big picture, and they won't understand it if its full of holes' (https://www.gapminder.org/data/documentation/ accessed February 20 2022)

[7] We highlight this point by using, in the description of sources (Appendix I), the words count, enumeration or 'census' between brackets rather than census

size and capabilities of the civil service, and especially of its native staff. In many cases, such as the Dutch East Indies (Boomgaard-Gooszen 1991), the accuracy of official sources has been improving over time thanks to learning by doing and to greater resources. In India the geographical coverage of British-organized censuses was progressively extended to native states (Davis 1968). These improvements are a mixed blessing as they might bias upwards the rate of growth of population if they reduce the gap between counted and real population.

The problem of reliability is deemed most serious for Sub-Saharian Africa, where most 'censuses' were a mix of information from village chiefs and guesswork by colonial administrators (Kuczynski 1937, 1948-1953). Table 2 tests this claim by comparing the total population with the estimates for the same polities/years by Frankema and Jerven (2014) [8].

Table 2
The reliability of colonial censuses

Number	British	French	Italian	Total
Total	24	12	6	42
ratio <0.9	14	7	3	24
ratio>1.05	4	3	1	8
Average ratio				
total	86.1	87.7	95.8	96.0
ratio <1	77.5	80.9	67.8	77.2
ratio>1	112.0	140.4	127.5	122.6

The results are somewhat better than expected: only about a half of censuses are seriously undervalued (ratio census/estimate less than 0.9), while a fifth are overvalued (ratios over 1.05). The (unweighted) average ratio implies a very low undervaluation. Unfortunately, these reassuring results do not help much our work, as almost all these censuses were taken in the 1920s and 1930s: before World War One official sources for Sub-Saharian Africa are extremely scarce.

Historical demographers have integrated the missing or defective official data with (variants of) three methods, the use of 'experts' estimates, the backward projection and the forward projection

i) 'Experts' were (usually Western) people, explorers, missionaries or diplomats, who put forward population estimates in books, travel accounts, memories, official dispatches and the like. These figures have been widely used, but are to be handled with caution. Most 'experts' had personal experience of limited areas only and applied their knowledge to the whole territories of interest. E.g. the early navigators estimated the population of Oceania islands by looking at coasts, or at tracts of them, and making wild inferences on the population of the (unobserved) interior. As a result, the population figures varied a lot: for instance, the members of the Cook expedition estimated the population of Hawaii to range between 240 and 400K (Nordyke 1989 13). Furthermore, in some contested areas, 'experts' were politically motivated: according to Karpat (1985 p.4), the estimates for the Balkans 'strongly reflect the political biases

[8] The French and Italian data refer to 'censuses' as reported respectively from Statistical Yearbook France and Statistical Yearbook Italy while for British colonies we rely on the list by Kuczynski (1948- 1953). We include only colony-wide censuses, dropping area-specific enumerations (e.g. for the capital city and its surroundings), approximate counts or guesstimates.

of the writers or of their informants and worst of all, in some of them the statistics were blatantly manipulated or falsified outright'.

ii) The backward projection method have been widely used for Africa, following the pioneering work by Manning (2010, 2014). The starting point are population censuses for 1950, which have been endorsed by the United Nations, in spite of some doubts about their reliability [9]. He extrapolated them backwards to 1850 with area-specific coefficients, which he estimated by adjusting upwards or downwards the decadal rate of growth of Indian population (Davis 1968) according to the evolution of each African macro-area (e.g. the intensity of slave exports) [10]. Frankema and Jerven (2014) have used also rates of change in Indonesia and the Philippines, as land-abundant areas closer to the (West African) factor endowment, and have modified the adjustment coefficients to take into account demographic shocks. Last but not least, in still unfinished work, Manning and Nickleach (2014) have further refined the method for the period 1650-1890, taking into account the age and composition of the population and also the slave flows, both outside and inside the continent.

iii) the forward projection method has been used to estimate the population of Pacific islands at contact, the time of first arrival of Europeans (Kirch and Rallu 2007). The method is highly speculative, as it needs hypotheses about the time of first settlement of each island, the number of first settlers and the rate of growth of the native population, which depends on the natural increase, on migration flows on and the frequency and impact of demographic shocks. Thus, whenever possible, the authors supplement their extrapolations with archeological evidence on the number of sites or on agricultural land use, with additional hypotheses, respectively, on the rates of occupation rates of dwelling and of the extraction of surplus by the élites. However, also the archeological evidence must be used with caution, as sites might have been occupied at different moments in time (e.g. within a slash-and burn agricultural system)

4) The construction of our data base

The whole data-base features a total of 174 series, of different length, from 1800 to 1938 for a total of 21815 observations. We detail the sources and methods of estimation in Appendix I, while here we discuss only the general criteria

First and foremost, in order to get a world total, we cover all polities, even if there are no solid data but only guesstimates or nothing at all. Second, unlike Maddison and Gapminder, as a rule, our series refer to polities at current borders. This solution is historically more sensible and avoids the adjustment to different borders, which would have needed additional information and/or guesses, increasing the risk of errors, without any obvious advantage. Thus, the list of polities differs in time following changes in the political map. Just to take the most extreme example, our data-base includes a series for Austria-Hungary until the dissolution of the empire in 1918 and then separate series for the successor states, Austria, Hungary,

[9] Frankema and Jerven (2014) discuss at length the shortcomings of African post-war censuses and reckon that they undervalued population by about 8% (221.7 million vs 240 million). Also the Latin American post-war censuses were undervalued – cf. the discussion by Yanez et al (2012). They correct the pre-war censuses, as far back in time as 1817 for Cuba, with a polity-specific constant coefficient (on average about 6%). The assumption of a constant bias contrasts with the results of an earlier comparison between censuses and other demographic sources by Collver (1965).

[10] In the first application of his method for the West African countries, Manning (1988) used as baseline the data from pre-war colonial censuses and assumed steady rates of population growth 0.5-1%.

Poland, Czechoslovakia and the Kingdom of Serbs, Croats and Slovenians (later Yugoslavia), while Tyrol and Dalmatia are included in the Italian population. However, we apply this rule with some flexibility. We extend series for African colonies to 1800, as there are no information about pre-colonial polities, we estimate series for Italy and Germany before their unification, in 1861 and 1870 and we keep separate Belgium and Netherlands during their short-lived political union in 1815-1830. We estimate separately series for Ottoman territories in Europe and in Asia, in order to get consistent continent-wise series, while we treat formally Ottoman territories in North Africa (e.g. Algeria and Tunisia before French conquest) as separate polities. Of course, we have taken as much care as possible to avoid omission and double counting of territories.

In theory, we are aiming at measuring present population at mid-year. We prefer present (de facto) rather than resident (de jure) population, as most historical (and present-day) censuses (Thorvaldsen 2018 p.156), because it minimizes the distortions from domestic and international migrations [11]. Our series include all present people, including military personnel, and, most notably, natives. The issue is very relevant for some colonies and especially in countries of Western Settlement, which often treated native population separately in official sources, as in Australia (Smith 1980) or omitted them altogether, as the United States before 1890. Their omission would severely bias the results, as the share of natives on total population collapsed for the joint effect of the decrease in their absolute number and of immigration of white settlers (e.g. natives were over 90% of the Australian population until 1825, a third in 1850 and a mere 2% on the eve of World War One). The series for white settlers only were bound to underestimate total population at any specific moment in time and to overestimate its growth.

We have tried to follow as much as possible these criteria but this has not been possible in very many cases. For each polity, we have chosen the series or, when not available, the benchmark year figures which seem more solid. Whenever possible, we use country specific sources or population and area specific data-sets such as Rothenbacher 2002 for Western Europe and 2013 for Central and Eastern Europe and Bulmer-Thomas (2012) for the Caribbean. We rely on general purpose data-base by Mitchell (2007) and Maddison (2010) only as a last resort [12]. When data are insufficient or dubious, we have taken into account trends in comparable polities and also the 1950 population of the polity. The United Nations (2019) report figures for all polities in the world, as we assume them to be accurate, although many of them are estimates. We have filled gaps between figures for benchmark years with linear interpolation while we have estimated any missing years at the end or, much more frequently, at the beginning of the period by taking into account trends in the polity (or in in neighbouring ones) in adjacent years [13] When possible, we have corrected the

[11] If the local population registers are not updated, the resident population would be greater (smaller) than the present in countries or regions of emigration (immigration). The distortion was quite large in Russia, where former peasants resisted cancellation from the registers of village population as this entailed the loss of their right to access to common land. This effect caused official series to be overstated by about 5% of the population - i.e. by about 8.5 million (Markevich and Harrison 2011 Appendix tab A8).

[12] Actually the most comprehensive source on historical population used to be the data-base POPULSTAT by J.Lahmeyer, which however seems to be off-line as of March 2021. It reported figures for total population at current borders, without attempting to fill gaps nor, a fortiori, to compute world-wide totals. The references list included a large number of contemporary reference works (e.g. Statesman Yearbooks or the Almanach Gotha) and world atlases, while the author seemed unaware of historical data-base such as Mitchell and Maddison (2010) and of the country-specific historical literature. Thus, we do not use it

[13] In quite a few cases we have estimated population changes in the 1930s by taking into account the implicit rate of growth from 1938 to 1950 and in the 1950s (United Nations 2019). These latter can be considered, given the pattern of demographic transition, an upper bound of rates in the pre-war period.

linear interpolation with data on the impact on population of demographic crises, such as famines or epidemics in any specific year of the period. In particular, we have used the information on deaths from the Spanish flu from country-specific sources and from the recent paper by Athukorala and Athukorala (2020)[14]. In contrast, we cannot correct linear interpolations with yearly data on international migrations because these latter are usually available for countries with good population registers and thus annual population series. Last but not least, when possible we have adjusted end-year annual data to the mid-year by averaging two consecutive years.

Africa, the Arabian peninsula and Oceania need some further comments. We have estimated separately with polity-specific sources the series for the six North African countries, for eight small islands and for South Africa after 1910. There are no sufficient sources for as many as 31 polities – almost the whole Sub-Saharian Africa and thus we have had to rely on the backward extrapolations by Manning and Nickleach (2014) and Frankema and Jerven (2014) [15]. Table 3 compares their estimates for macro-areas in three benchmark year [16].

Table 3
Estimate of African population, 1800-1950 (millions)

		Northern	Northeast	Central	West	East	Southern	Total
Manning et al. 2014	1800	24.9	21.1	18.7	47	31.8	7.8	151.3
Manning et al. 2014	1850	27	20.8	16.1	46.2	30.9	8.3	149.3
Frankema et al.2014	1850	12.8	28.5	20.8	25.9	22.1	4.1	114.1
Manning et al 2014	1890	28.2	20.7	15.6	46.4	29.8	8.7	149.4
Frankema et al. 2014	1890	19.4	28.2	24.4	31.8	24.4	6.2	134.4
Frankema et al.2014	1950	44.3	31.1	31.3	64.0	34.1	17.1	221.8

The differences in rates of change for Sub-Saharian Africa are not so large from 1890 to 1950 (0.66% for Manning-Nickleach 2014, 0.83% for Frankema and Jerven 2014), when both use a similar approach, but

[14] As a rule, we allocate the excess deaths to 1918 and/or 1919 with information of timing of the epidemic and we estimate population change until 1917 extrapolating previous rates of growth and then we interpolate linearly to the next available figure

[15] The polities are Angola, Botswana (Bechuanaland), British East Africa, Cameroon, Congo, Eritrea, French Equatorial Africa, French Somalia, French West Africa, Gambia, Ghana (Gold Coast), Guinea Bissau, Lesotho (Basutoland), Liberia, Madagascar, Malawi (Nyasaland), Mozambique, Namibia (German South West Africa), Nigeria, Rwanda and Burundi, Sierra Leone, Spanish Guinea, Somalia (jointly Italian and British), Sudan, Swaziland, Tanganika (German East Africa), Togo (German West Africa), Western Sahara, Zambia (Northern Rhodesia) and Zimbabwe (Southern Rhodesia).

[16] In this table, following Manning and NIckleach 2014 Map 1.1, West Africa includes French West Africa (present- day Mauritania, Senegal, Guinee, Ivory Coast, Dahomey, Niger, Upper Volta, Mali), Togo, Liberia Guinea Bissau, Gambia, Nigeria, Ghana (Gold Coast) and Sierra Leone, Central Africa includes, Cameroon French Equatorial Africa (present-day Central African Republic, Chad, Gabon, Congo-Brazzaville), Equatorial Guinea, Angola, Belgian Congo, Malawi (Nyasaland) and Zambia (Northern Rhodesia), Northern Africa includes Morocco, Western (Spanish) Sahara, Algeria, Tunisia, Lybia and Egypt, North-East Africa Somalia, Djibouti, Eritrea, Somalia and Sudan, East Africa includes British East Africa (Kenya and Uganda), Mozambique, Madagascar, Tanganyka, Rwanda Burundi, Southern Africa includes South Africa, Namibia (German South-West Africa), Botswana (Bechuanaland), Lesotho (Basutoland) and Zimbabwe (Southern Rhodesia).

wide in the previous forty years. Ultimately, we prefer to use the Frankema-Jerven series from 1850 onwards. [17] The Manning-Nickleach series (2014) are still provisional and refer to macro-areas which do not coincide with colonial polities. Their very sophisticated modelling strategy needs a lot of assumptions about unknown parameters, such as life expectancy, rates of survival of slaves after capture, division of surviving captives (as slaves) between Africa and overseas markets etc. Furthermore, Manning and Nickleach (2014) in their main projection assume that, after the end of the slave exports to the Americas and until 1890, the number of captured people in each sub-region remained as high as at the peak of transatlantic trade [18]. We use the Manning-Nickleach (2014) rates of change by macro-region to extrapolate backward to 1800 the population by polity in 1850. It is the only available estimate, and anyway the figures for slave export are based on the Eltis data-base on transatlantic voyages.

Official sources for polities in the Arabian peninsula are totally lacking (except the British colony of Aden) and estimates are scarce, partial and/or wide off the mark. Thus, we use a 'Manning-type' approach: we extrapolate backwards the 1950 UN figures by hypothesizing that their population grew by 0.3% yearly from 1800 to 1870, 0.6% from 1870 to 1914 and by 1.3% yearly from 1914 onwards (roughly the rates of neighbouring countries)

The case of Oceania is somewhat different. The colonial censuses for the 20th century are deemed reasonably accurate and indeed in most cases the results tally well with the United Nations data after 1950. In contrast, trends in the 19th century are very controversial. Traditionally, historical demographers have relied on estimates from 'experts' and in the second half of the 19th century on enumerations by missionaries. These latter were fairly well aware of the size of their flock and of potential converts and indeed the results of their enumerations are often confirmed by later censuses. In contrast, the early estimates by 'experts' often differed quite widely. The historical demographers have given more weight to figures closer to the late 19th century ones, discarding some early estimates as implausibly high and thus they have downplayed the decline in population after the contact (McArthur 1967, Campbell 2006). On the other hand, the forward projection method yields much higher figures, similar or even higher than the present-day population. This implies a large collapse in population, which was caused by the 'fatal impact' with European diseases. The most controversial case is population of the Hawaii. The consensus among historical demographers settled for a figure in the middle range of the quoted estimates by members of the Cook expedition, even if Schmitt (1972) argued strongly for a low figure. In contrast, Stannard (1989), put forward a range of 0.8-1 million at contact in 1778 (double the population in 1940) hypothesizing the arrival of about 100 people in the first century AD and a 0.52% yearly rate of population growth. Later work has used so-called Dye-Tomori model, which relies on changes in the charcoal quantities in archeological sites to build an index of population movements (Kirch 2007). Extrapolating backward the earliest reliable figures yields a population at contact close to the lower bound of the historical demographers' estimated range. In our estimation, unless we have additional polity-specific evidence (e.g. on major epidemics or on civil wars), we have adopted a conservative view. We have assumed that population were stable before the

[17] We have re-computed the Frankema-Jerven (2014) series for Ethiopia, because the website by mistake reports a constant population. We do not discuss separately these series in Appendix one, unless, as for Congo or South Africa, there are alternative modern sources.

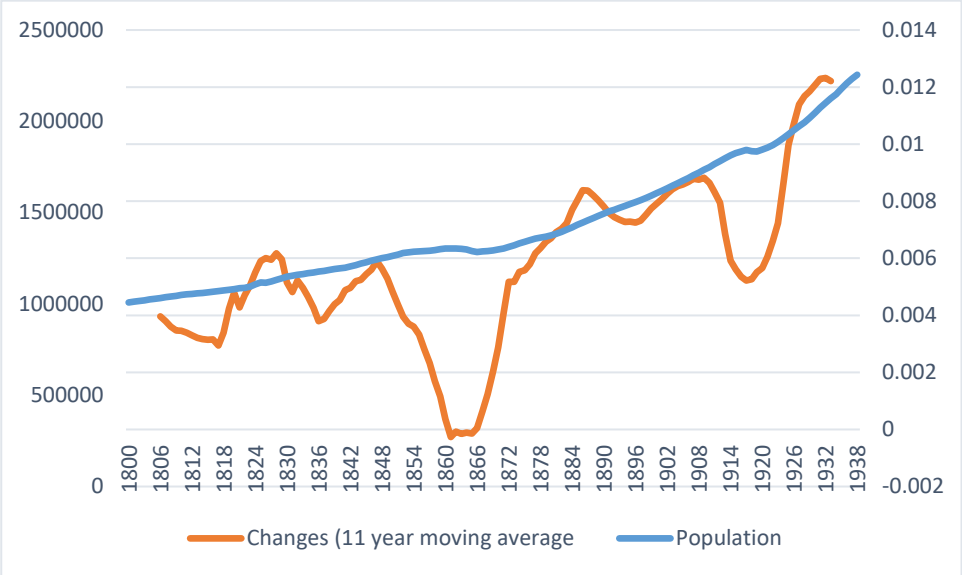
[18] This assumption would underestimate the population of the slave-exporting areas if, as equally likely, total exports had instead declined. The bias in estimates of the African population would be equal to the difference between actual and hypothesized captures for slaves exported outside the continent. In contrast, the enslavement of people in other Africa areas would affect mostly the polity-specific series, while total African population would differ only by the additional deaths in capture and by the difference in birth rates between freed and captive population. Frankema and Jerven (2014) do not quote the slave trade after 1850 and we assume that they take it into account in the adjustment of reference rates.

start of substantial interactions with Europeans (which in most cases began later than the first contact) and that it declined after it at different rates, not exceeding 2% per year, until the earliest reliable figure.

5) The results: world population in the long run

Overall, the world population increased from just above 1 billion in 1800 to 2.2 billion, which corresponds to a log rate of 0.54%. A visual inspection (Figure 2, left axis) suggests an almost linear increase but the joint TS/DS model by Razzaque et al (2007) returns a not significant rate. Indeed, the yearly changes (even when smoothed with a 11 year moving average as in Figure 2, right axis) show two massive decelerations, in the mid-19th century, and in the late 1910s.

Figure 2
World population and its yearly change 1800-1938



A Bai-Perron (2003) test singles out five breaks in 1824, 1846, 1866, 1886 and 1919 and Table 4 reports (left-hand column) the rates of change for corresponding intervals, plus (right-hand column) additional medium term rates

Table 4
Rates of change, world population, 1800-1938

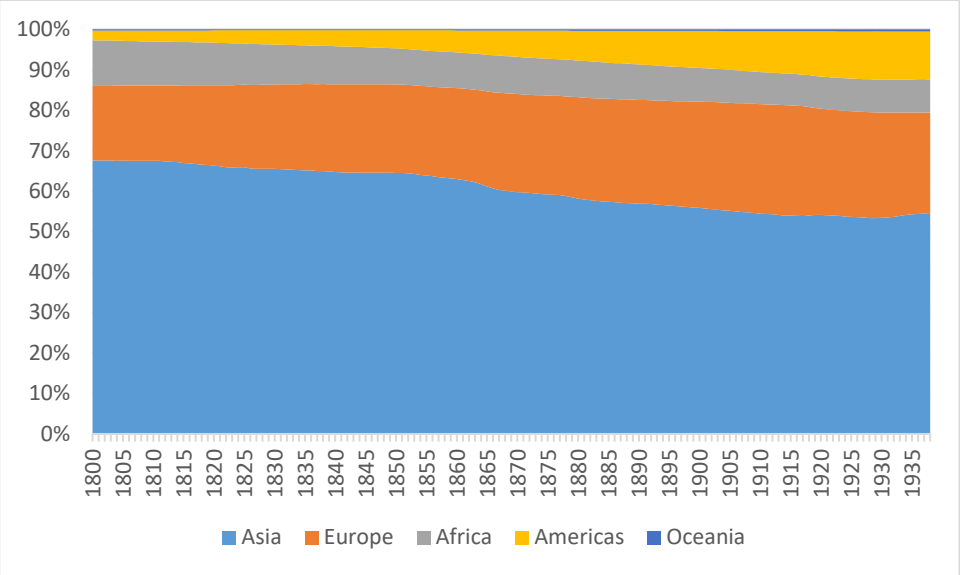
	Short term °		Medium-term
1800-1823	0.32***	**1800-1850 °°**	0.50***
1824-1846	0.47***		
1847-1866	0.20***	**1850-1864°**	0.20***
1867-1886	0.62***	**1865-1913°°**	0.78***
1887-1919	0.77***	**1913-1920°**	0.29***
1920-1938	1.17***	**1920-1938°**	1.17***

° log linear; °° Razzaque et al (2007)

World population grew in the first half of the 19th century roughly as much as in the 18th century, if one believes in the available estimates [19]. The growth accelerated in the 19th and 20th century, to culminate in the second half of the 1960s with rates around or above 2% per year.

The time pattern of growth differed substantially between continents, as Figure 3 shows

Figure 3
The distribution of world population by continent, 1800-1938

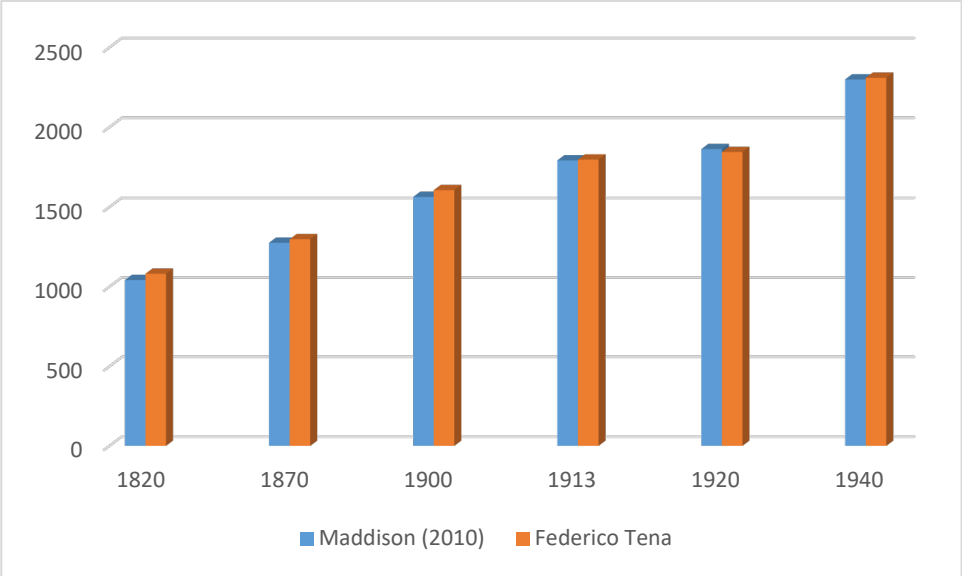


In relative terms, the African and Asian population declined, the European (here including the whole of Russia) increased and the American and Oceanian boomed. The changes were already massive by 1870 and were mostly over on the eve of World War One. Trends slowed down or even reversed in interwar years, but total changes were small in comparison with pre-war ones. The African share of world population fell by a fifth in the first half of the 19th century, from 11.3% to 8.9%, slid by a further percentage point to 7.8% in 1913 and in 1938 was roughly at the level of the mid 1900s. The Asian share declined over the whole period by 13 points, from 67% to 55% and a third of the change was cumulated in the 1850s and 1860s. Likewise, two thirds of the relative rise of Europe from 18% in 1800 to 27% in 1913 were cumulated before 1870. The European share fell during the war by one point and continued to decline afterwards. In contrast, the American share rose almost as fast from 1870 to 1913 (from 6.5% to 10.4%) than in the first seventy years of the century (from 2.5% to 6.5%) and rose further to 11.9% in 1918.

[19] The rates for the 18th century hover around 0.4% per year, ranging from 0.33% for Clark (1967) to 0.46% for Maddison (until 1820) and to 0.48% according to HYDE 3.1 (Klein Goldewijk et al 2010). This latter suggests a slowdown in growth from 0.57% in 1700-1750 to 0.39% in 1750-1800, but it is an exception. All other estimates report higher rates in the second half of the century - e.g. McEvedy Jones (1978) 0.33% in 1700-1750 and 0.45% in 1750-1800.

We will return to the causes of these change in the next sections. Before that, we need to ask to what extent our results modify the conventional wisdom about long term trends. We start by comparing population at the relevant benchmark years with the main alternative estimate, by Maddison (Figure 4) [20]

Figure 4
World population, 1820-1940: a comparison with Maddison

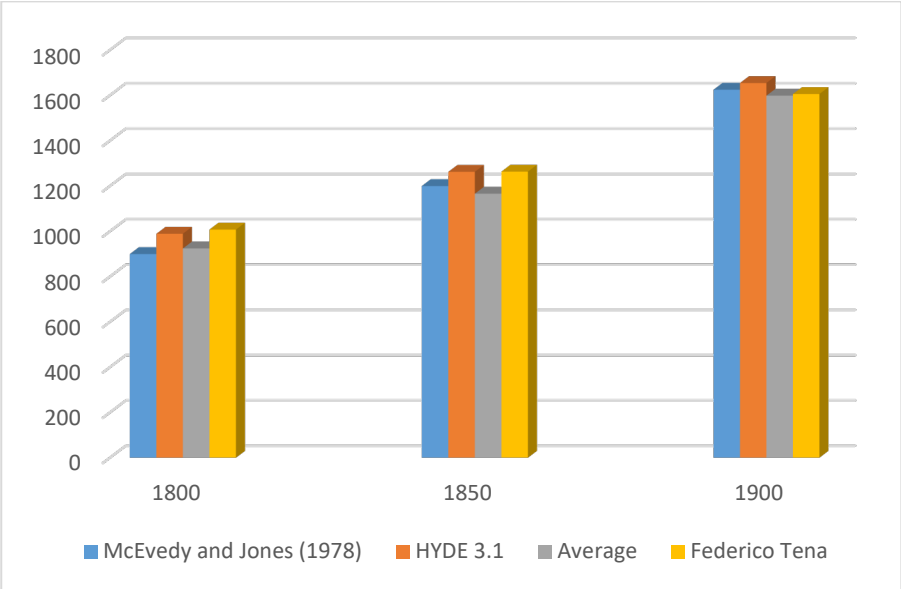


The differences in long-run rates of growth to 1940 (0.63% the present estimate, 0.66% Maddison) are small and this is a strong evidence of Maddison's unique historical skills [21] On the other hand, there are non negligible divergences in the time profile. Our estimate is 3.4% higher than Maddison in 1820, very similar in 1913 and lower by 1% in 1920 [22]. Thus, Maddison's data overestimates by some percentage points the cumulated growth from 1820 to 1913 (by 66% vs 72%) and over the 1910s crisis (almost 4% vs 2.5%).

The differences between our estimates and other series are somewhat greater, at least in the 19th century. In Figure 5 we compare our results with two widely quotes estimates by McEvedy and Jones (1978) and HYDE 3.1 (Klein et al 2010) and with an average of other major independent ones[23]

[20] For the purpose of this comparison, we compute the population in 1940 by extrapolating our estimate of population in 1938 with the growth rate for the previous five years (1.3% for Asia and Africa, 1.2% for Americas and world population, 1.1% for Europe and Oceania).
[21] One may add that the RMSE for the comparable yearly series, which however refer mostly to advanced countries with good sources, is quite low – around 10%.
[22] The population in 1940 is computed, for comparative purposes only, by extrapolating the rates of growth by continent in 1934-1938 – and thus it might be overstated as it does not include an adjustment for war-time losses.
[23] The average is computed on seven sources common to all three benchmarks, Willcox (1940), Carr-Saunders (1936), Swaroop (1951), Bennett (1954), Durand (1967), Biraben (1979) and United Nations (1999). We add Clark (1967) in 1800 and 1900 and Hubner Geographical Atlas (as quoted by Willcox 1940) n 1851 and 1900. We do not add a bar for the late 1930s because the estimates refer to different benchmark years.

Figure 5
World population, 1800-1900: a comparison with other estimates



Our estimate is higher than all others in 1800 (up to 10% higher) and it grows more slowly.[24] As expected, differences by continent are greater (Table 5), and they are clearly related to the abundance of sources [25]. They are fairly small for Europe (without Russia), and quite large for Oceania and Africa. These latter would have been larger if we had used the Manning-Nickleach (2014) estimates also for the period 1850-1890 (cf. Table 2).

[24] Our estimate implies an annual rate of growth 0.47% 1800-1900 vs 0.51% for HYDE 3.1, 0.59% according to McEvedy and Jones (1978) and 0.55% for the average, with a maximum of 0.63% according to Durand (1967).
[25] In the columns for the average of estimates, the cells 'Europe' (excluding Russia) and 'Russia' are empty because they treat differently Russia, sometimes reporting separate figures and sometime including in Europe.

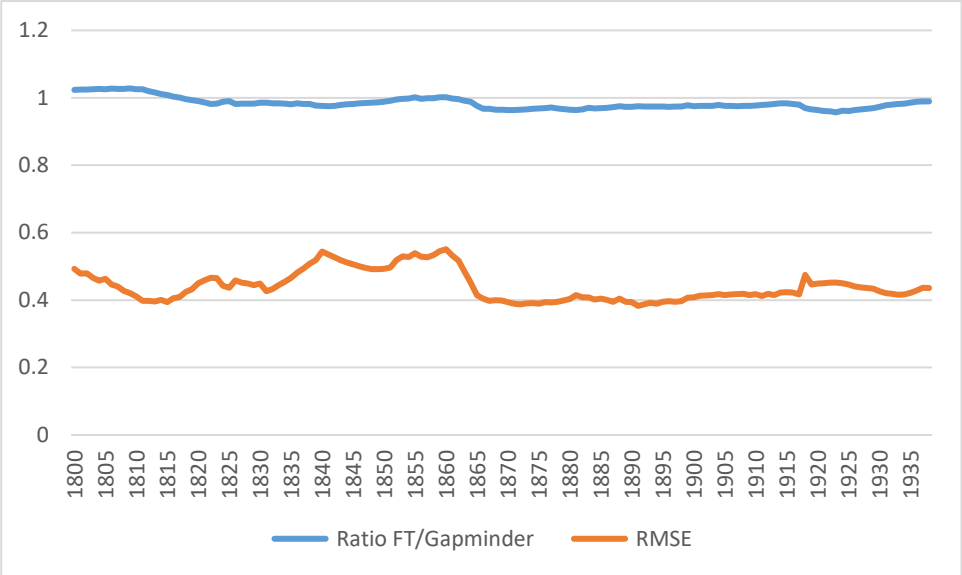
Table 5

Comparison with other estimates, ratios by continent

	McEvedy-Jones (1978)			HYDE 3.1			Average 'core'			Maddison		
	1800	1850	1900	1800	1850	1900	1800	1850	1900	1820	1900	1940
Africa	1.63	1.39	1.22	1.33	1.09	0.95	1.16	1.11	1.03	1.53	1.22	0.98
America	1.01	0.97	1.01	0.88	0.95	0.99	0.89	0.95	0.93	1.01	1.00	1.00
Asia	1.10	1.04	0.95	1.00	0.99	0.96	1.11	1.08	0.98	1.01	1.03	1.01
Europe	1.01	0.99	0.99	0.98	0.97	0.96				0.96	0.94	1.04
Russia	0.89	0.94	1.08	0.88	1.09	1.11				0.90	1.08	0.88
Oceania	1.23	1.11	0.97	3.61	1.95	1.25	1.41	1.33	1.10	6.27	1.45	1.33

Finally, Figure 6 compares the present estimate with the yearly series in the Gapminder website, computing also the RMSE to measure the polity-specific differences [26]

Figure 6
Comparison with Gapminder



The Gapminder series, as other estimates, overvalues the growth of population relative to the present one, in the 'long' 19th century but the difference is not large. In contrast, the short term movements are quite different (the correlation between the cyclical components from Hodrick-Prescott filters is a mere 0.48) and the RMSE is very high (44% on average). The RMSE is to some extent boosted by an imperfect adjustment of present-day borders to historical ones, but some large differences (e.g. for India) are difficult to explain [27]

The League of Nations is a somewhat different case. Its estimate is very similar to the present one in 1913, with a modest 17% RMSE and again in 1925 (the present estimate is about 1% higher and the RMSE is down to 10%), but diverges sharply in the 1930s. In 1938 our estimate is 5% higher and the RMSE is 42%. Most of this divergence depends on a different assessment of trends in China. The League of Nations puts forward an 'approximate estimate' with stable population at 450 millions for the whole interwar period, while according to our estimate (and consistently with the first post war census in 1953) the Chinese population rose from 454 in 1925 to 530 millions in 1938.

These comparisons show that the so far available series capture long run trends in world population, given the unavoidable margin of error of all estimates, including the present one (cf. Section eight). In contrast, yearly series are either missing, as in most scholarly works, with the partial exception of Maddison, or of

[26] We compute the RMSE on a set of comparable polities to avoid bias results upwards. Anyway, the omitted polities account for a very small share of total (less than 5%) for both Gapminder and the League of Nations

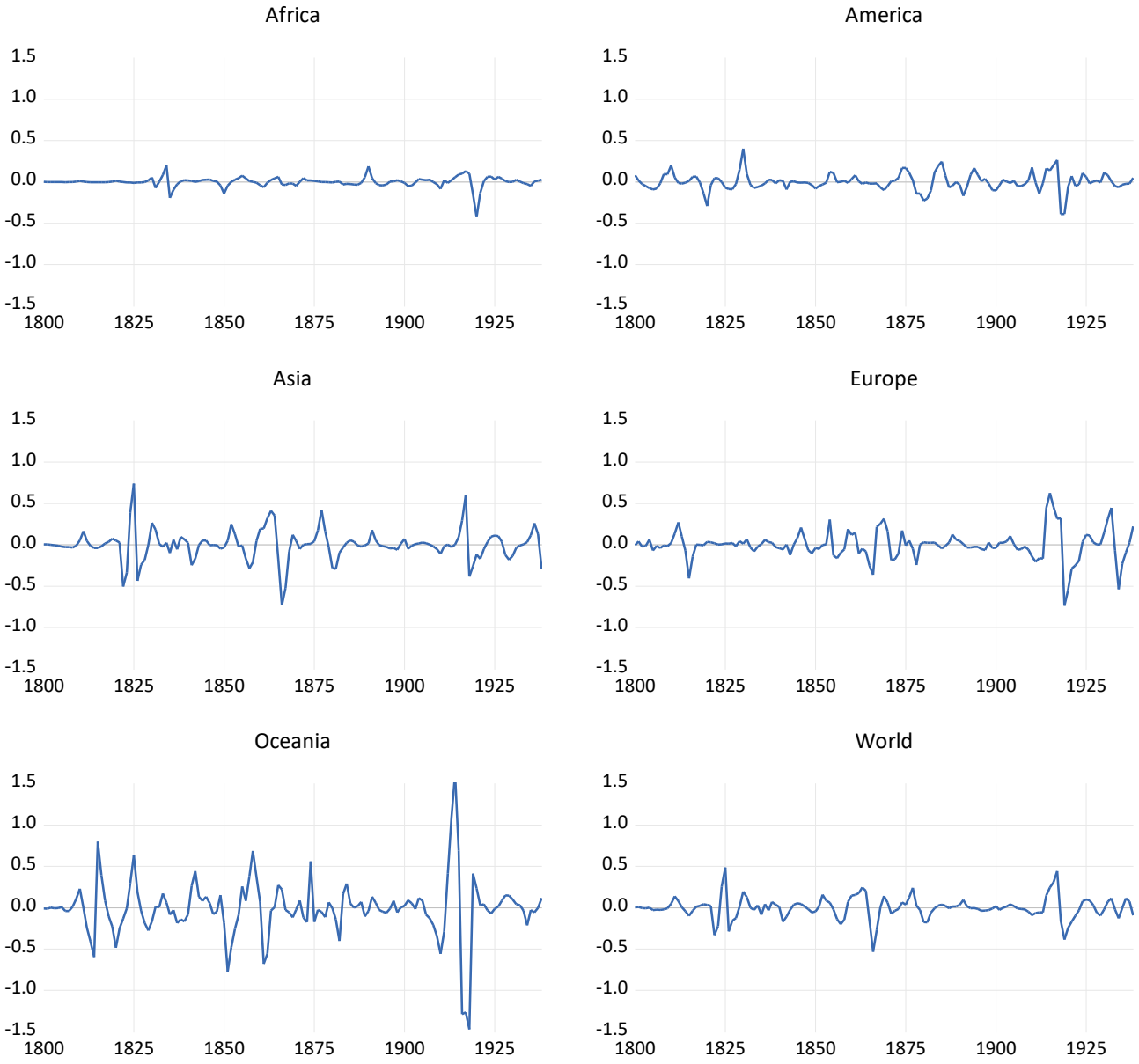
[27] The sum of Pakistan, India, Bangladesh and Myanmar according to Gapminder exceeds the population of British India according to censuses, as re-worked by Davis (1968) and endorsed by Maddison 1995 and Sivasubramonian 2000 by 17%, throughout the period. Such a divergence suggests some major difference in geographical coverage but it is impossible to find it with the available information on Gapminder sources.

questionable reliability for lack of information (for Gapminder). In the next Section we will use our newly compiled polity data for historical analysis.

6) The results: volatility and demographic **crises**

As a first step, we test the conventional wisdom about volatility, which we compute as the residuals from a Hodrick-Prescott filter and, as a robustness check, also with the normalized five-year difference as advocated by Hamilton for yearly series (2018). We normalize the residuals with the trend component and we plot them in Figure 7 for continents and world.

Figure 7
Volatility by continent



The results do not tally with the conventional wisdom. There is not a clear downward trend and volatility does not appear inversely related to level of development. It is high in Oceania but very low in Africa, and higher Europe than Americas and Asia. These results might be affected by the use of linear interpolations which by definition reduce volatility (cf Section Eight). This is surely the case of low volatility of African series, as almost all series for Sub-Saharian polities are obtained as five-years periods with constant rates - s (with a jump between them). Furthermore, a decline in share of series obtained with linear interpolation might balance the decline in volatility. We test this latter hypothesis by adding add the share as in our regression to estimate the rate of change in volatility. [28] The results (Table 6) confirm the first impression

[28] The dependent variables are computed as the logs of square root(s) of the ratios of squared numerator and denominator (e.g. the residuals and the trend component of the Hodrick-Prescott filters).

Table 6
Rate of change in volatility of population series, 1800-1938

	HP		Hamilton
	1800-1938	With share	1800-1938
Africa	3.17***	3.66***	3.21***
America	2.20***	1.70	-0.09
Asia	0.78	0.71	1.18**
Europe	3.23***	3.77***	0.13
Oceania	1.28	1.25	1.90***
World	1.10	1.00	0.80***

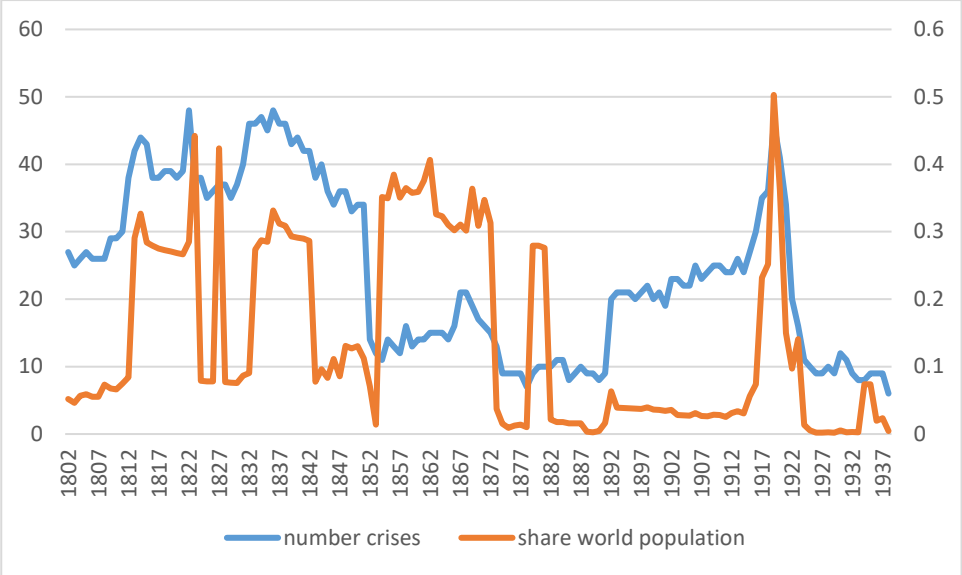
There is no consistent sign of declining volatility with either method, with or without the share of interpolated observations as control. If any, the variance increased, but results, with the exception of Africa, are not consistent enough to draw any firm conclusion.

Volatility depends on demographic crises. In theory, one could define a crisis any observation sufficiently below trend (e.g. by two SD lower), but results would be biased by the use of linear interpolations. We thus adopt a more conservative definition of crisis as absolute decline in population, for whatever reason (epidemics, famines, wars) [29]. Out of a total of 21423 yearly changes by polity, population increased in 17461, remained constant in 979 and declined in 2983 i.e. about a sixth. The contrast with the 5.3% share in 1951-1991, before the start of mass emigration which reduced population of several Eastern European countries.

The distribution in time of these crises (Fig 8) shows a sharp drop in the second half of the 19th century, and then a rise which peaked, predictably, in 1919 with the Spanish flu.

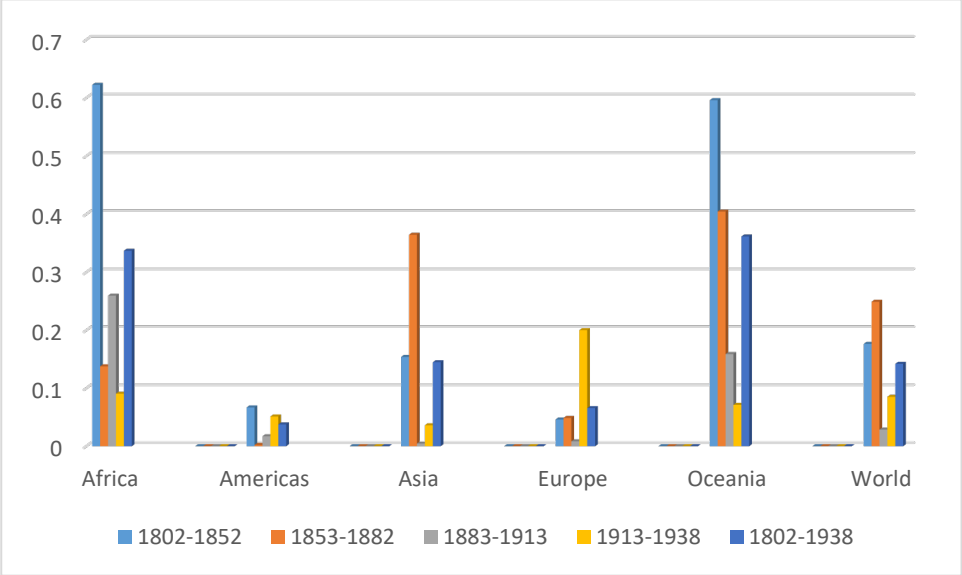
Figure 8
Number of crises and share of world population

[29] We adjust only for declines in population caused by territorial losses, as in France in 1871 and Germany and Russia in 1919. We assume that in that year, population changed as much as in the average of the two neighbouring years (e.g. 1870 and 1872). We need not to adjust for the dissolution of Austria-Hungary and of the Ottoman empire because the series end in 1919.



However most affected policies were small and indeed the effects on world population, as measured by the share of population in affected policies (Fig 9), are smaller. In the first half of the century, crises affected mostly Africa and Oceania, around mid century Asia (or, more precisely China) and in after 1913 Europe, while the thirty years before World War One, the heyday of first globalization, crises were very rare outside Africa, which were hit by the rinderpest and European conquest [30]

Figure 9
Share of population affected by demographic crises, by period/continent



[30] According to the estimates by Frankema and Jerven (2014), Africa accounted for almost two thirds of all crises in 1883-1913 (340 out of 576). In those years, population declined in 13-15 polities in SubSaharian Africa (out of 41) with between a third and a quarter of the population.

Our definition, as Table 7 shows, captures two very different categories of 'crises', short and severe shocks and long run, slower, downward trends [31]

Table 7
Duration and severity of demographic crises

	Number crises	Years of crises	Yearly decrease	Average cumulated decrease
One year	56	56	-3.11	-3.11
Two years	51	102	-1.14	-3.85
Three years	18	54	-2.53	-7.38
Over three years	157	2983	-0.56	-10.68
Total	282	3195	-1.53	-5.83

The worst demographic shocks plagued the tiny island of Cabo Verde, which, in spite of its name, was subject to disastrous droughts. There were five such crises, and in the worst one, in 1830-1832, population collapsed from 76K to 47K – i.e. by 45% . The Irish famine and related diseases claimed 1-1.5 million lives, but the total population of the island fell, because of emigration, from the peak of 8.3 million in 1845 to 6.3 in 1852 – i.e. by a quarter (Mitchell 1988). As a consequence, the total population of the United Kingdom declined, in spite of the fast rise elsewhere in the country, from 1846 to 1851 by about 3%. The devastating famine of North China 1877-1878 claimed between 9 and 13 million lives (Aird 1968 p.265): in the most affected province, Shanxi, ca 5.5 – i.e. about 15% of population (and just for a comparison over a third of the population of UK in those years).

The long run downward trends accounted for over 90% of 'crises' in our definition. The worst case is the Danish Virgin island where, according to the estimates by Bulmer Thomas (2012) population declined in 91 years out of 139 – i.e. in all years but the initial ones (1800-1835), the final ones (1930-1938) and a short period of stagnation from 1846 to 1850. However, downwards trends were longer and more frequent in Sub-Saharian Africa and Oceania: the former accounted for more than half of observations in long run trends (1565 out of 2983) but the latter had proportionally more, 41% vs 28%. The exact timing, speed and duration of these long crises is uncertain as the rates for these continents are, at best, informed guesses, but the evidence for these long-term crises is overwhelming. In Africa the population declined because of

[31] There is no good independent source on demographic shocks. The EMDAT data-base (https://www.emdat.be/) deal with natural disasters only since 1900 and it seems to underestimate the number of deaths. It lists 387 events, but in only eight cases the death toll exceeds one million people

the slave exports (Manning and Nicleach 2014), in other continents because of European infectious diseases which natives had little or no immunity against. By 1800, the collapse of native population had already happened in South America and in Mexico, was on-going in North America and had just started in Oceania. The extent of population decline depended on the type of diseases and on the population density. Some diseases were more lethal than others and transmission depended on intensity of contacts. The wide spaces of North America reduced contacts between infected native groups (Thornton 2000) and the length of trips from Europe might have initially slowed down transmission of some diseases (Bushnell 1993). Yet, our source suggests a 62% decline of native population of North America 1800 to 1890 (Thornton and Marsh-Thornton 1981). In Oceania the decline of the native population was as large as in the Americas and there was very little rebound before World War Two. According to the best estimates, the total aboriginal population of Australia fell from 541K 1800 to 71K 1936 (i.e. by 87%). Yet the impact of these demographic catastrophes on world population was small and sometimes negligible. If the native population had been growing at 0.5% yearly since 1800 rather than declining, the population of Oceania would have been 2.3 million higher in 1938 and the world total only 0.1% greater. [32] In the extreme and somewhat implausible case that the 1800 native population were ten times the historical minimum, as hypothesized by Stannard (1989) for Hawaii, the population Oceania would have been 8 millions (vs 3) but world population would have been only 0.5% higher. Even major human tragedies barely affected long term trends. The African rinderpest killed about 0.5% of world population, the North Chine famine 0.6-0.9% world population.

Indeed, the world population declined in only eight years out of 139, in 1826, 1862-1866 and in 1918-19. The first one is the consequence of a sudden fall in Chinese population, from 392 to 385 million, which however does not correspond to any known catastrophe and thus might well be spurious. The 1862-1866 decline it coincided with the bloodiest phase of the Tai'ping civil war. In the fourteen years from the 1852 peak, when the war had just started, to 1871, when the last Tai'ping army was defeated, population collapsed from 439 to 359 million (i.e. by almost a fifth), and about half of these losses were cumulated in 1862-1866[33]. The 1917/19 decline was determined by three different shocks, the Great War, the Russian post revolution famine and civil war and the Spanish flu. Table 8 compares the actual population changes for selected countries and European belligerents with a crude estimate of excess mortality[34].

Table 8
Population changes 1917-1919

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[32] For Australia and New Zealand we obtain the counterfactual series as sum of natives and white population with data from Historical Statistics Australia and Historical Statistics New Zealand. For Hawaii we rely on data from Schmitt (1968 tab 16 and 26). We estimate the counterfactual series for full-blood natives only, while we include 'part Hawaiians in the series for 'others' (mostly Japanese immigrants), assuming there were 100 'others' in 1800. For other islands the sources do not distinguish between natives and immigrants, who anyway were much fewer than in Hawaii or, a fortiori, Australia and New Zealand. Thus, we implicitly assume that all population was native-born and we select for the counterfactual the period of absolute decline -i.e. 1800-1885 for Polynesia (a total decline of 50%), in Micronesia 1830-1913 (37%) in 1820-1901 Melanesia, without Papua New Guinea (-29%). We extrapolate the population in the final year of the period with the actual growth rate.

[33] The excess deaths, extrapolating the rate of the late 1840s (0.4% year) could be up to 110 million. The figure is higher than standard estimates of war losses as it includes also the losses from other revolts in the 1860s and deaths from famine and diseases. It is however close to recent Chinese estimates (Platt 2012 p.308)

[34] Cf. for Indonesia and India Appendix I. For the other countries we compute excess mortality as the difference between actual and counterfactual population in 1918 and 1919. We estimate this latter by extrapolating the actual population in 1917 (or 1918), thus inclusive of previous war losses and deaths from the first wave of the flu, with the 'normal' rate of change, as proxied by the 1909-1913 rate. For Russia we use the series at interwar borders from Markevich and Harrison 2011 tab A7-A9.

	Actual change		Excess mortality	
	1917 to 1918	1918-1919	1917 to 1918	1918-1919
China	1405 (+0.32%)	760 (+0.17%)	-1147 (0.26%)	-1800 (-0.41%)
Indonesia	-1072 (-1.97%)	523(+0.98%)	-1690 (-3.10%)	-82 (-0.15%)
India	-8966 (-2.79%)	1460 (+0.46%)	-8965(-2.77%)	-3031 (-0.93%)
Russia	-774 (-0.45%)	-1756 (-1.21%)	-3520 (-2.07%)	-4075 (-2.79%)
WWI belligerents*	-2247 (-0.78%)		-4866 (-1.71%)	
World	-6218 (-0.34%)	-2644 (-0.14%)	-22519 (-1.22%)	-18899 (-1.01%)

*excluding Russia, USA and dominions

Our estimate implies that the flu caused about 33 million deaths, but figure could be somewhat underestimated [35]. These data are not available for most countries and thus they have been substituted by rough guesses. Thus, the number of covered countries and the results differ rather widely, from 17-24 million (Spreeunwenberg et al 2018) to 35-44 million deaths (Athukorala and Athukorala 2020), with unsubstantiated guesses up to 100 million[36]. About 10-12% of world population has been estimated with linear interpolation between benchmarks or, as in the case of Africa, with constant rate of change over the period 1915-1920[37]. Furthermore, the figure of 3 million deaths in China, where anyway the flu might have been more benign than elsewhere (Chen and Leung 2007), is lower than current estimates of the losses, varying between 4 and 9.5 million deaths (Johnson and Mueller 2002, Athukorala and Athukorala 2020 Barro et al 2020). On the other hand, it seems highly unlikely that the true total losses reached 40 million. This conclusion implies that the Tai'ping civil war, or more in general the mid-19th century crisis, was the largest demographic shock in the whole period. In absolute terms is comparable to, if not higher than, World War Two, when world population was double a century earlier.

The impact of these two world-wide crises can be measured with a simple back of the envelope counterfactual exercise. We compute no-crisis population series assuming that the Chinese population had been growing from 1851 to 1871 as fast as in 1830-1850 and that the world population had been growing 1914-1919 as fast as in 1890-1914 [38]. The comparison of the three counterfactual estimates (Figure 12) shows that the Tai'ping war affected world population much more than the later 1910s crisis: world population in 1938 would have been 2429 million, rather than 2254 (or 7.7% greater) without the civil war

[35] This figure is obtained as residual deducting from the total excess death (40.8 million) the non pandemic deaths in Russia (4.8 million) and WWI belligerents (about 3 million). These latter are computed by deducting the available estimates of pandemic deaths (Athukorala and Athukorala 2020) from the total losses. This latter source does not cover all countries (missing Bulgaria, Romania, Serbia) and thus we use the upper bound of the implicit range. Total war losses, including diseased soldiers, were about 1.8 millions in Russia and 6.7 millions in other European countries (Becker 1999 p.80).

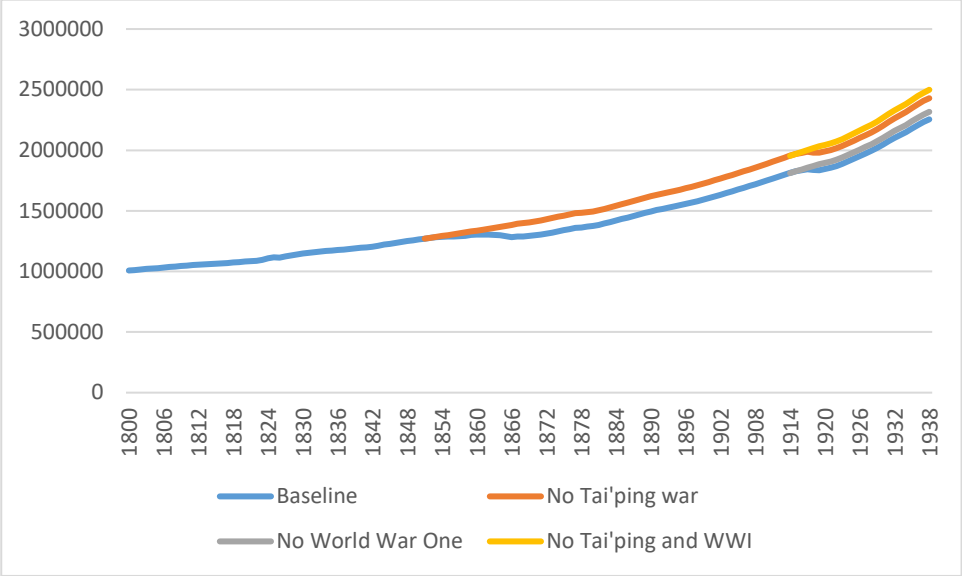
[36] This figure, which is often quoted in the historical literature, is a speculative guess by Johnson and Mueller (2002). The sum of their country estimates yields a total of 33-43 million, but they increase it to 50 million, and add that even this figure 'may be substantially lower than the real toll, perhaps as much as 100% understated' (p.115). See for other estimates of total losses Athukorala and Athukorala 2020 tab 1.

[37] Johnson and Mueller (2002) hypothesize a total of 2.4 million deaths in Africa, but, given the state of sources, this figure is pure guesswork.

[38] We extrapolate the post crisis trend with the actual rate, which could exceed the steady state one to compensate for the losses. However, there is no much evidence of such an acceleration. The rates for China were marginally higher in the mid-1870s than in the 1840s but the increase was short lived. As said, the worldwide rate of growth rose gradually from 1921 to the eve of World war rather than jumping after the end of crisis and then returning to the normal.

and 2137 without the late 1910s crisis (2.8% greater). Without both major crises, the population in 1938 would have been about 244 million greater (10.8%): if one factor in also the 'minor crises' the total losses might well exceed 300 million.

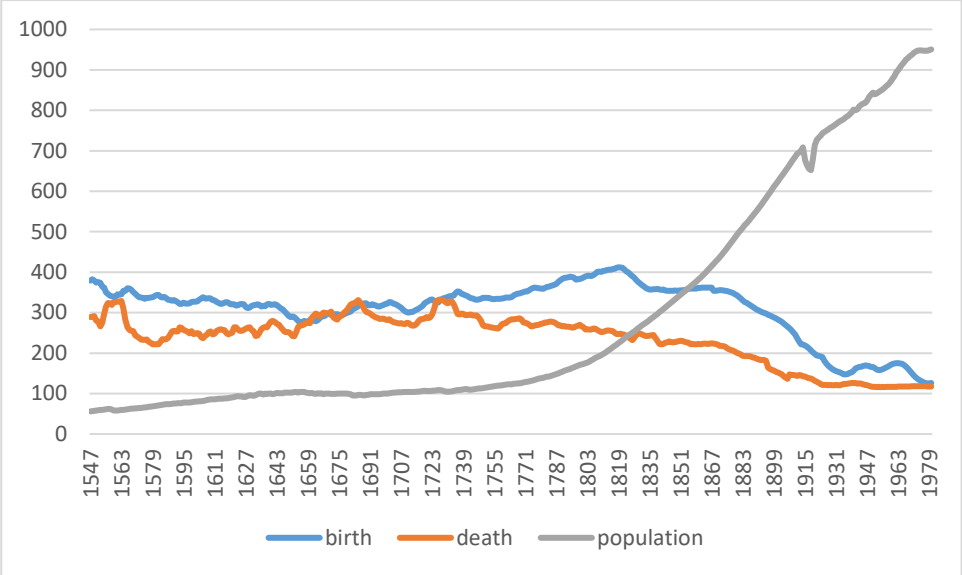
Figure 10
Counterfactual, no-crisis series of world population



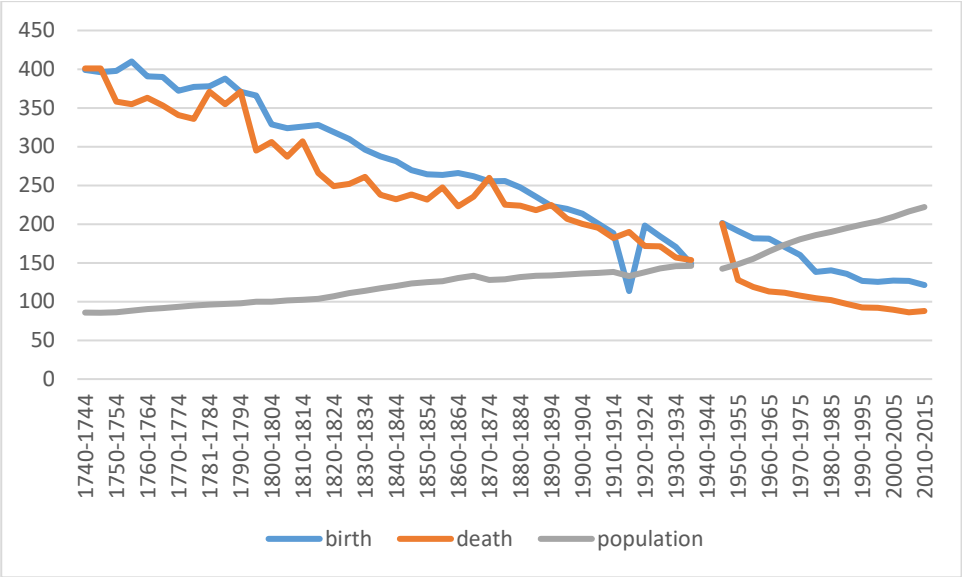
7) The results: dating the demographic transition

The textbook model of demographic transition (Kirby 1996, Lee 2003) implies an inverted U-pattern of the rate of natural increase of population. It is nil or very low before the transition, rises in the first stage for the reduction of mortality while fertility remain high and eventually return to very low (or zero) levels in the second stage, when fertility converge to mortality levels. This pattern would cause a permanent upward shift between two (almost) constant population levels. As all textbook models, also this one does not necessarily correspond to historical patterns, as Figure 11 shows, with two examples of major European countries, with suitably long demographic series.

Figure 11
The demographic transition in history (rates per thousand)
a) United Kingdom, 1541-1980



Sources: Mitchell 1988



Data in five years averages for data constraint Birth and death rates per thousands; population index 1800-1804=100

Population Henry and Blayo 1975 tab 22 for 1740-1800, our estimate 1800-1938, Annuaire Statistique 1945-1949, United Nations 1950 ff; birth and death rates; Henry and Blayo 1975 tab 22 1740-1830, Annuarie Statistique 1913 1830-1850, Rothenbacher 2002 1850-1945, Annuaire Statistique 1957 1945-50, United Nations 1950-2015

Even if movements of birth and death rates do not conform to the model, the transition did cause an increase in population. Indeed, population growth would be a perfect proxy for the transition if net migrations were zero. This is by definition true for world-wide population and thus our results (Section five) over the whole period implies that transition had started in the 19th century and it has been accelerating in the first half of the 20th century. In the early 1950s, the rates were already higher than the pre-war peak (1.7% vs. 1.3% in 1929-1933) and grew to 2% in 1965-1970, to decline to 1.1% in 2015-2020 (United Nation

2019). The world-wide increase is however consistent with a wide range of possible patterns by country (or area). Indeed the comprehensive, if not necessarily accurate, post-war United Nations data confirm the different timing of transition. The rates of natural increase have been consistently very high in Africa, up to a maximum of 2.9% in the early 1980s, initially high but declining in Asia and Latin America since the 1960s, fairly low (in the region of 1.5%) and declining in North America and in Oceania, initially low (ca 1%) and falling fast down to stagnation or decrease in Europe. One would thus infer that by 1950, the demographic transition was in the final stage in Europe, North America and Oceania, while it was in the ascending stage in Asia, Latin America in Africa. Unfortunately, the available pre-war data on rates of natural increase (Section Eight) are insufficient to pursue further this analysis. The coverage is partial even in the interwar years (about a half of the countries and a third of observations) and it is very limited in the 19th century.

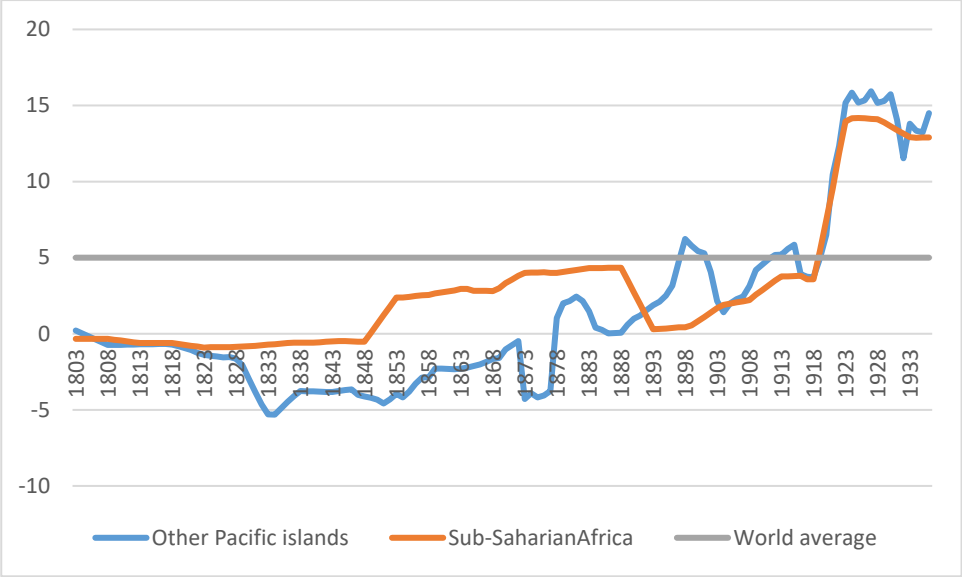
A first look at rates of total population growth by polity highlights a major difference with post war trends. Rates over 2% were the norm after 1950 but fairly rare before 1938 . The 2% threshold, which was the norm at peaks after WWII, was very rarely attained: yearly increase of 11-year averages exceed 2% only in 11% of cases (2215 out of 19718) [39]. Most of these cases are inflated by immigration, and not only in the usual suspects but also, for shorter periods, in countries, such as Malaysia (Kim 1998), Hawaii (Nordyke 1989) and possibly Mauritius (Lutz and Wills 1994).

We explore in more detail the pattern by grouping polities in nineteen areas, taking into account location, level of development and migration balances[40]. We then plot five year moving averages of population growth in these areas, ranking them (roughly) according to long-term growth rates and adding a 50 per thousand line to mark the world long term average rate (Figure 12)

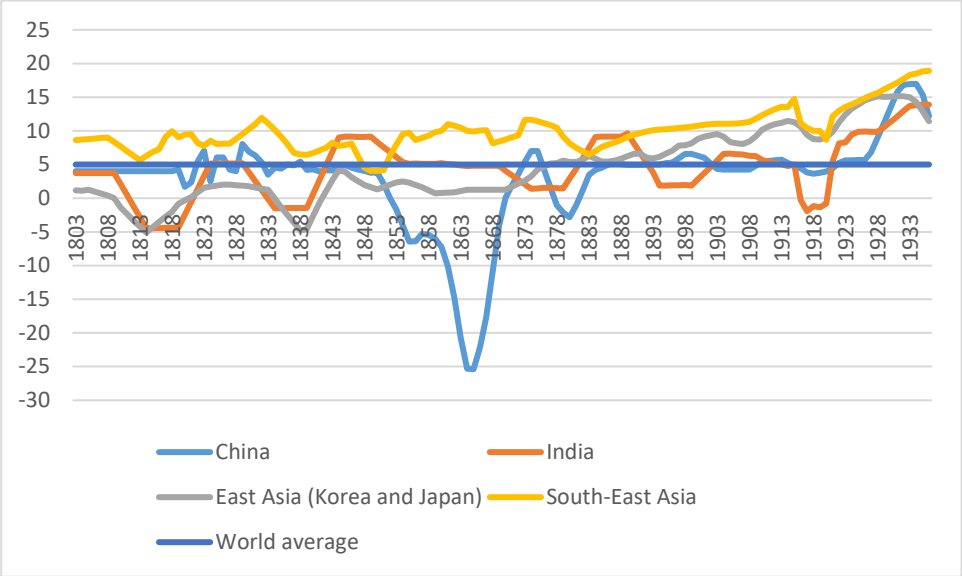
Figure 12
Rates of growth in population growth by area, five year moving averages
a) demographic crises: Pacific islands and Sub-Saharian Africa

[39] As a rule, we omit from computation of 11-year averages the initial and final years. Therefore, most series run from 1806 to 1933 and other are shorter – e.g. the series for Poland (original series from 1919 to 1938) refers to 1924-1933.

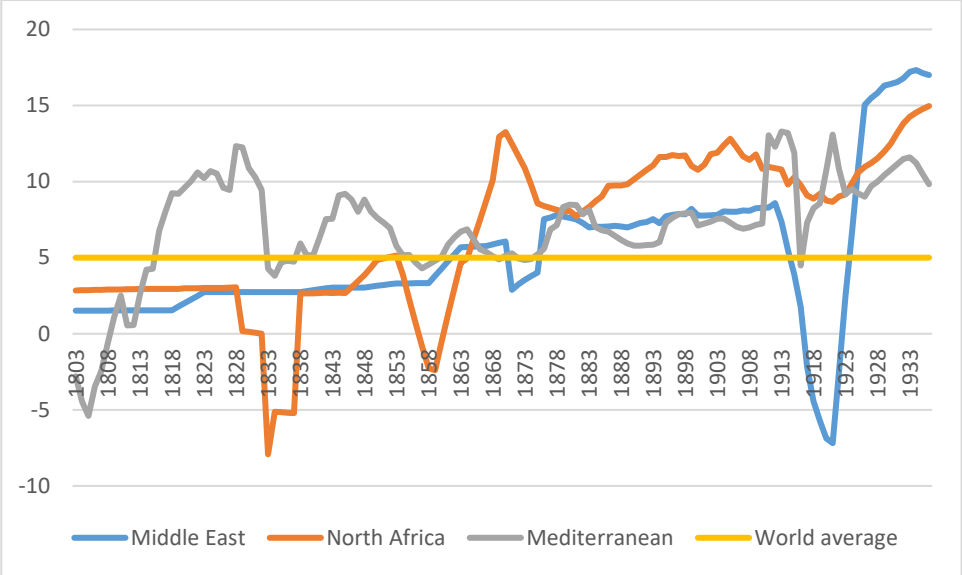
[40] We divide America between North, immigration areas (Brazil, Argentina and Uruguay), Oceania between Immigration (Australia and New Zealand) and the rest (Micronesia, Melanesia and Polynesia), Africa between North and Sub-Saharian, Asia between Middle East, China, India, South East Asia (Indonesia etc), East Asia (Japan and Korea). Europe between United Kingdom, other North Western (France, Scandinavia etc.), Central (Germany, Austria-Hungary and successor states), Southern (Italy, Spain, Portugal), Eastern (Russia, Poland after 1918) and Balkans. For the sake of readability, in the series for Balkans and Central Europe we omit all averages including the year 1919, to avoid the spurious effect of boundary changes between countries belonging to different areas. In that year, the Southern provinces of the former Habsburg empire (included Central Europe) was transferred to Yugoslavia (included in the Balkans).



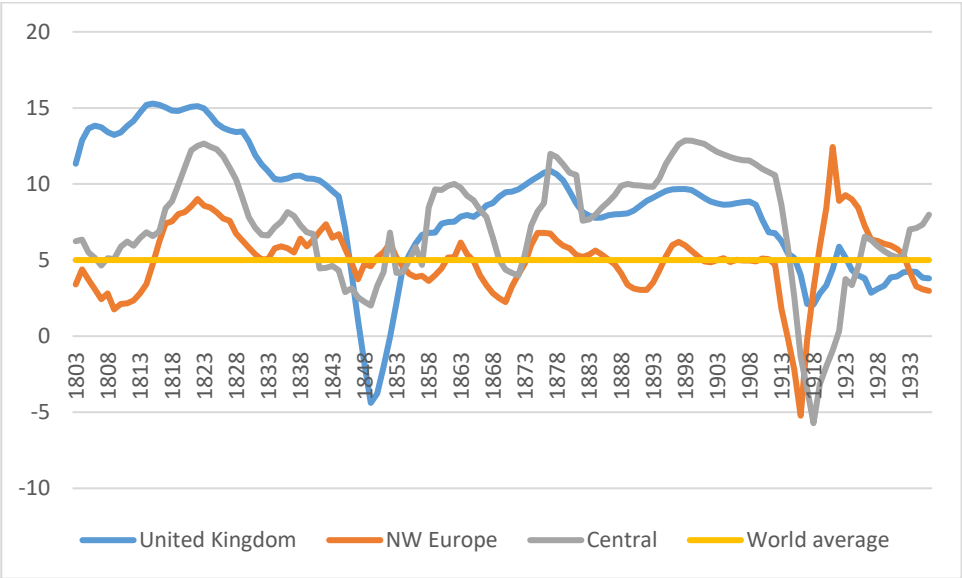
b) traditional societies: Asia



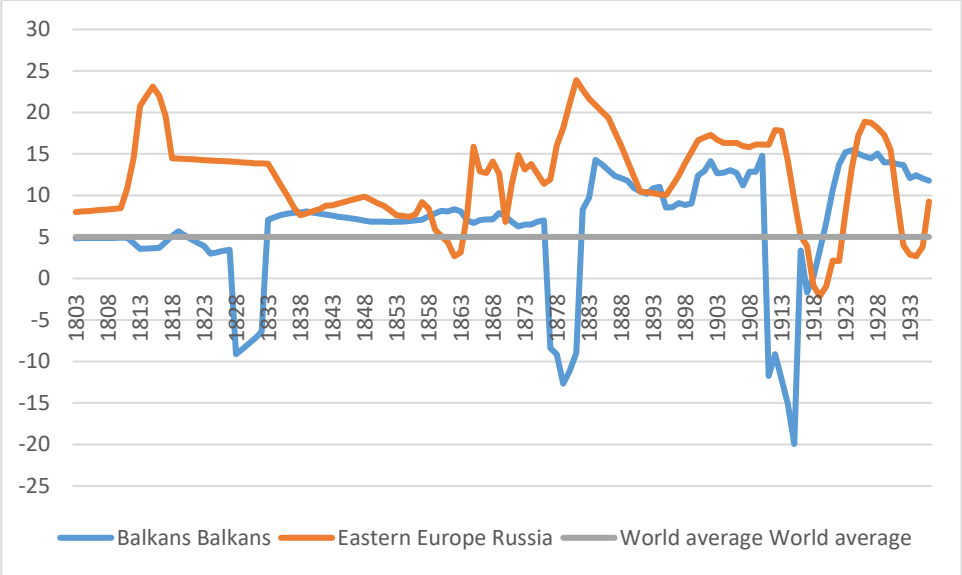
c) Traditional societies: Mediterranean



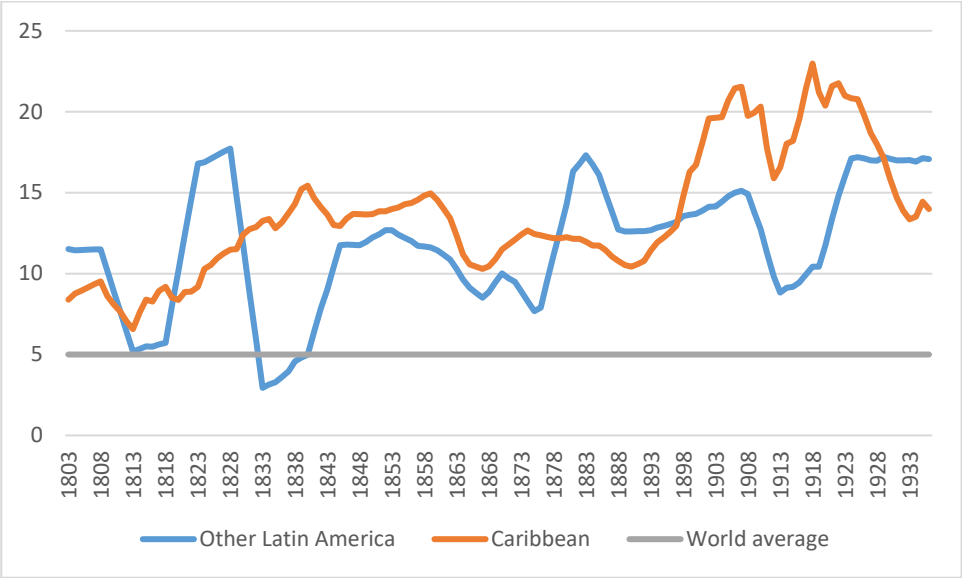
d) advanced Europe



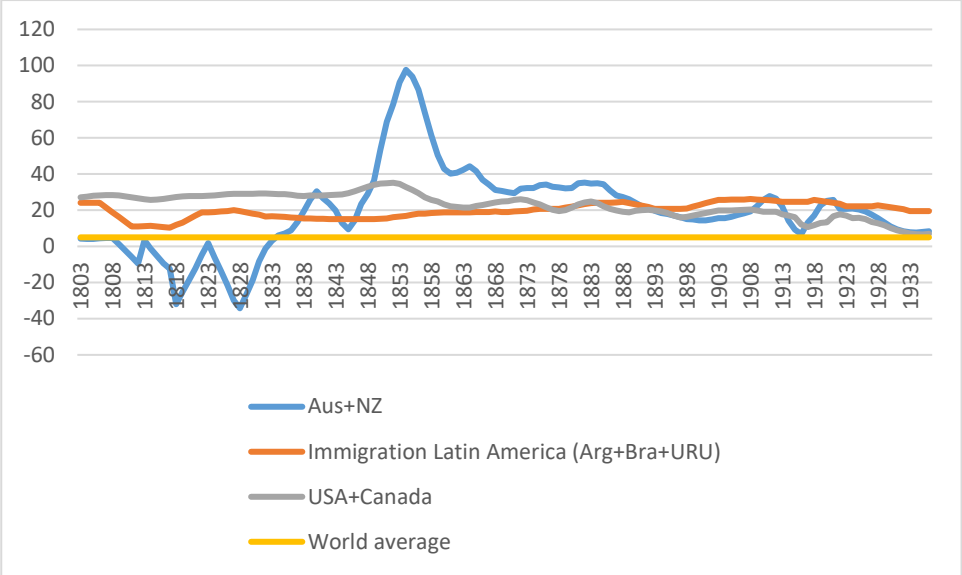
e) traditional societies: Eastern Europe



f) traditional societies: South America



g) immigration countries



A visual look suggests six stylized facts

i) as expected, population grew very fast in immigration countries, with the notable exception of Australia and New Zealand in the first half of the 19th century, for the collapse of native populations. But the growth was not only from immigration: the rates of natural increase were very high, at the top of the world scale at least before World War I. In the United states, the (estimated) rate remained above 2% until the mid 1850s and declined below 1% (well above the world average) only during the Great Depression

ii) the rates of growth in advanced European countries were rather low in the first decades of the 19th century (with the partial exception of pre-famine United Kingdom) and declined further in the period, with some major fluctuations in Germany. These trends suggest that these countries were starting the final stage of demographic transition [41].

iii) in North Africa, East and South-East Asia the pattern resembles the textbook model of the transition. The population stagnated until the 1860s or 1870s and then it started to grow at accelerating rates. The rates exceeded 1-1.2% in the 1930s. and then grew further after the war, with maxima well above 2%. In none of these areas, the transition can be considered complete as rates of total (and natural) increase still exceeded 1% in 2015-2020.

iv) In Pacific island and Sub-Saharian Africa population had been stagnant or declining in the early 19th century and thus the fast growth of interwar years included a substantial component of rebound. On the

[41] In the 1930s, when migrations were negligible, the population growth was 0.4% per year in North-Western Europe (including France) and United Kingdom and 0.6% in Central Europe. In the 1950s and 1960s, the natural increase rose somewhat in Northern Europe (United Kingdom and Scandinavia), remained almost stable in Central Europe (France and Germany) but population rose faster thanks to immigration – up to 1% per year.

eve of World War One, population was 15% higher than in 1800 in SubSaharian Africa and 10% lower in Pacific islands. Given the poor quality of the data, it is difficult to interpret the pre-war trends as clear evidence of demographic transition.

v) in contrast, there is no evidence of accelerating population growth until the very of the period in the two most populous countries, China and India. Indian rates remained extremely low (less than 0.2%) until WWI, increased to about 1% in the late 1920s and to less than 1.5% in the late 1930s. The growth accelerated after WWII, peaking in the late 1970s-early 1980s. The Chinese population grew very slowly after the shock of the mid 19th century, with a short-lived acceleration in the mid 1930s. As in India, rates increased after the war, but the growth was modest for the combined effect of the disasters of the Great Leap Forward and of the of the one-child policy.

vi) last but not least, in quite a few cases, movements which can be interpreted as a beginning of the transition were interrupted by exogenous crises and had to re-start. The most relevant example is Russia/Soviet Union. The rate of population growth, after a first, temporary increase in the 1820s and a modest retrenchment in the 1840s-1850s, remained quite high (1.5% to 2%) from the 1870s to WWI. Total population more than doubled from 1850 to the eve of WWI. The growth resumed at quite brisk pace in the 1920s and then after World War Two, with high but declining birth rates (Rothenbacher 2012 tab. SU 4A). It is tempting to suggest that this decline could have started earlier without the disasters of wars and famine. In the Balkans, World War One caused a sudden stop to population growth, which then resumed at slightly higher rates (about 1.2-1.3%) in the 1920s and 1930s and continued after the war

8) Robustness checks: shall we trust these figures?

8.1 Our interpretation in two previous Sections would be the more convincing the more reliable the series are. Thus, in the first part of the Section we will assess the quality of the polity series and estimate the effect of errors following Feinstein and Thomas (2001). We assume a symmetric band as we have already taken into account in the estimation any evidence of asymmetric errors (e.g. of undervaluation of official statistics). Then we deal with two specific sources of bias, the extensive use of linear interpolation and the migratory flows, which affect respectively our analysis of the demographic crises and our use of changes in total population as proxy for natural increase. Linear interpolations make timing of demographic transition less precise and, above all it biases downward volatility and thus downplays the impact of crises. Net emigration (immigration) causes total population growth to underestimate (overestimate) the natural increase and thus to bias downward (upward) the extent of the first stage of transition.

8.2 We assess the reliability of the series by classifying separately each year/polity observation, following the pioneering work by Durand (1977). He distinguished four classes, from A (good quality censuses or well kept yearly population records) to D (pure conjectures) and reckons that class A figures account for 48% of the estimate of world population in 1900 by Clark (1967), B for 14% B and C for 38%. We expand his classification to five classes,

A ‘excellent’: fully trustworthy estimates, based on ‘modern censuses’ and/or complete population registers.

B ‘good’: interpolation between modern censuses and partial or not fully reliable censuses

C ‘fair’: interpolations between not fully reliable censuses or estimates by scholars with solid evidence

D ‘poor’: interpolations of C or estimates by scholars with weak evidence

E ‘conjectures’: all other estimates, including extrapolations for periods before the earliest available estimate

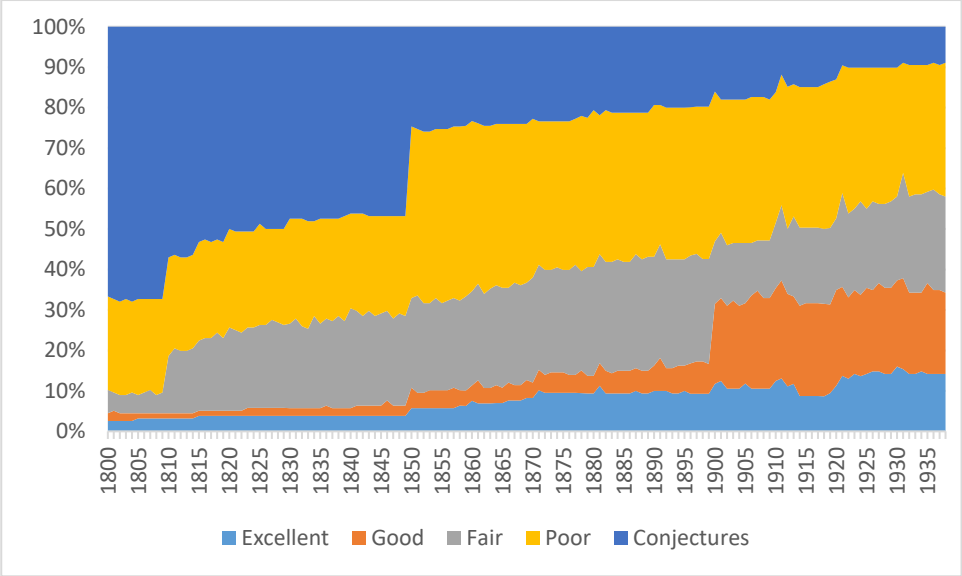
Our sources use the word census for a widely different range of population-counting exercises, but many of them do not fully meet the modern standards (and thus in Appendix I are labelled as ‘count’ or ‘enumeration’). A census can be defined ‘modern’ if was taken on a given date, possibly the same throughout the whole territory, counted all individuals (not just males and/or potential taxpayers), listed them separately with additional information (e.g. age, sex, occupation) and had data collected and elaborated by trained professional clerk rather than by local administrators or tribal chiefs (Baffour et al 2013). We define complete state-organized population registers of births and deaths for the whole population. On the other side of the reliability range, we reserve E for the most tentative figures. For instance, we classify as D the estimates by Frankema and Jerven (2014) for population in Sub-Saharian Africa 1850-1938 and as E our extrapolations to 1800. Some polity series are obtained as sum of differently reliable data – e.g. typically good ones for white settlers and guesstimates for natives. In these cases, we classify results with a crude weighting.

The unweighted shares of different categories (Figure ? a) paint a quite dismal picture. For most of the period, the number of polities with A-class (‘excellent’) estimates was very small and, is spite of some growth since the 1880s, on the eve of World War Two, they accounted for a mere 15% of all polities. The class includes only European countries until the 1870s, when the Japanese (and Korean) statistics improve substantially [42]. The number of E (‘conjectures’) fell drastically from two thirds to a mere tenth, but jointly with ‘poor’ estimates (D) they still accounted for two fifths of all observations in the late 1930s. However, most of these poor-quality series relative to small polities. The three most populous non-European countries, China, India and Russia, had a majority of C and D years, few Es (India) and also some Bs (Russia). Thus, the population-weighted shares (Figure ?) are less depressing: they show big spikes in census years and some improvement over time, but much less clear than for the trade statistics (Federico and Tena 2016). The A-class (‘excellent’) figures account for about 5% of the total in the early 19th century and grows to about a quarter on the eve of World War Two. Also the share of second best data (B or ‘good’) has been increasing – so that the two top categories accounted for almost a half of observation in 1931 (census year) and for a third in the late 1930s. On the other hand the progress was not steady: for instance the share of population in countries with C data (‘fair’) was quite high in the 1830s and 1840s, thanks to the good working of Chinese registration system, but collapsed after the outbreak of the Tai’ping war.

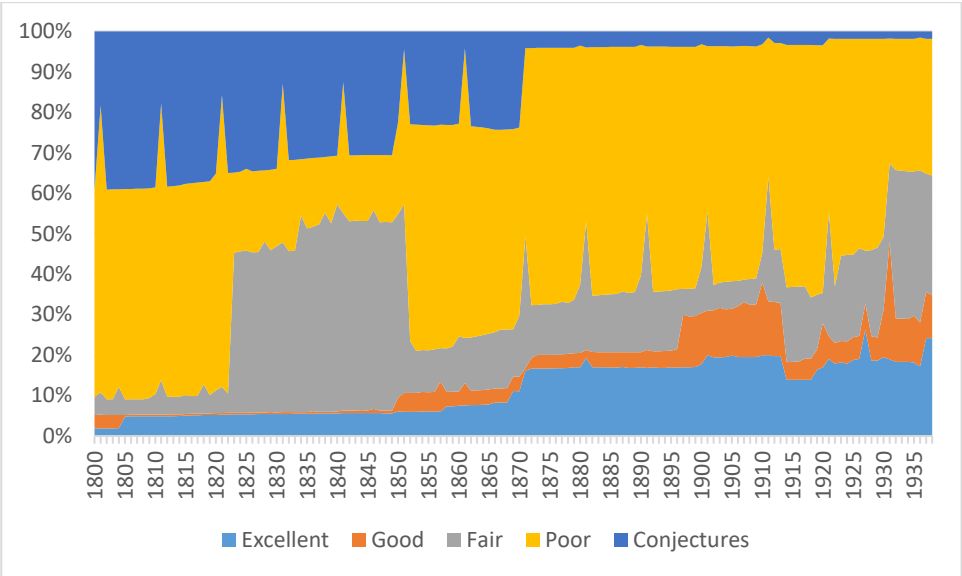
Figure 13
Distribution of world population by quality of data:

[42] The quality of data in countries of Western Settlement is not consistent with their high income. We have already quoted the shortcoming of American statistics (Section Three). The Australian and New Zealand data are uncertain until the early 20th century for the large but poorly counted native population. The Canadian censuses are fairly good after 1851 and very good in the 20th century but the official sources estimate intercensal population with linear interpolation.

a) unweighted



b) population-weighted

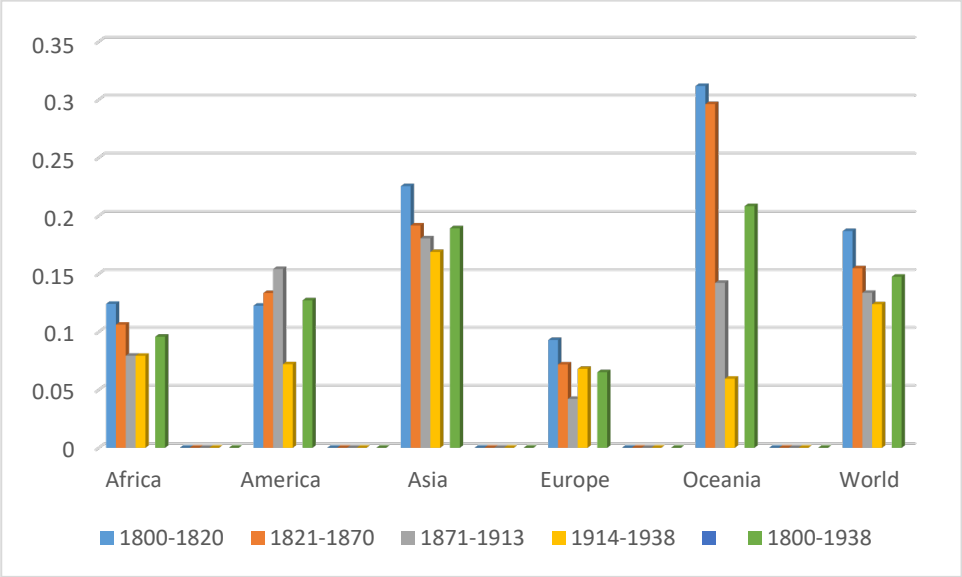


How much do the potential errors affect the estimates? Clearly, a major mistake in a polity series might jeopardize the interpretation of the demographic history of that polity but its effect on aggregate series depend on the size of the polity and on the possible compensating effects of opposite-sign mistakes in other series. By definition, it is impossible to detect mistakes in polity series without additional evidence – i.e. further research. It is however possible to compute the aggregate margin of error of estimate (Feinstein and Thomas 2002). We first attach a margin of error to each observation according to our assessment of its quality - 2.5% for A estimates (± 1.25% around the 'true' value), 7.5% for Bs (±3.75%),

17.5% Cs (±8.75%) 32.5% for Ds (±16.25%) and over 40% for Es (with band ±25%). Then we compute the standard error as the sum of variance, under the assumption that errors are independent. Almost all our population series are based on polity-specific sources, whose errors are likely to be independent. The exception might be the series for Sub-Saharian Africa, which are computed with similar rates by macro-area. However, errors will be common only if the true rates of change not only differed from the common one, but also equal across countries. Furthermore, the aggregate bias is small, as Sub-Saharian Africa accounted for only about 5% of world population.

The anecdotal evidence on the organization population statistics would suggest that the margins of error were lower for advanced countries and declining over time. This hypothesis is only partially confirmed by the movements in (normalized) standard deviation (Figure 14)

Figure 14
Standard deviation of estimates as share of population

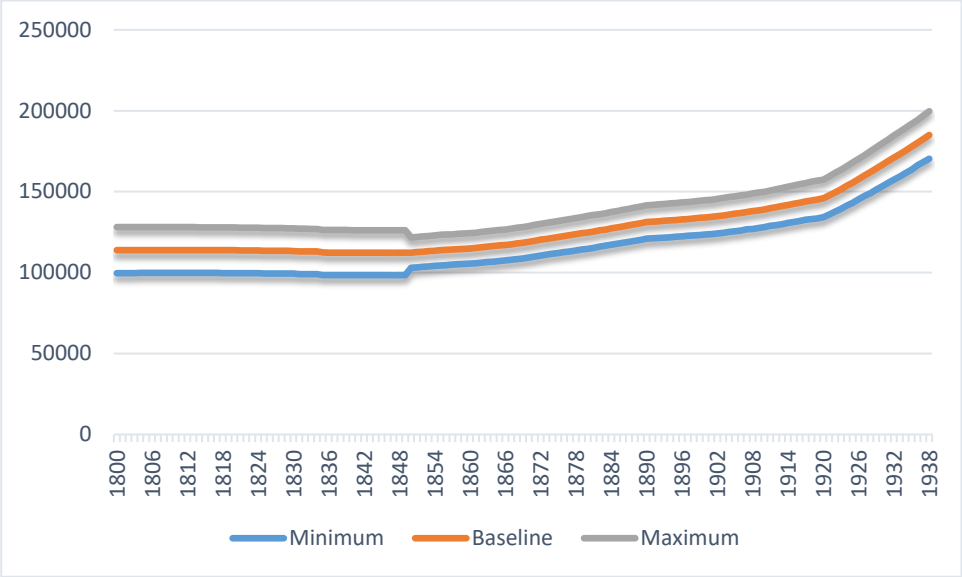


The world data show a modest improvement in time (from 18.7% to 12.4%) and, over the whole period a decidedly lower error for Europe (6.5%) than for other continents, including the Americas. Changes in Europe are heavily affected by the quality of Russian statistics: the 1897 census anchored firmly the registration data for about twenty year, but the quality deteriorated with the outbreak of the war (as in other belligerent countries) and hardly improved in interwar years, as population became a politically contentious issue in Soviet Union. The fairly high level of error for Americas and its increase before the war reflects the combination of (relatively) poor quality of United States statistics and of the relative rise of its population, from a quarter of the continent in the early 19th century to half after civil war. Last but not least, the spectacular decline in error for Oceania, from 31% to 6.5%, is a consequence of the change in composition of population – whites rising from 0.2% to 75%. In spite of its low share on world population, the fall in error in Oceania accounts for half the total world decline.

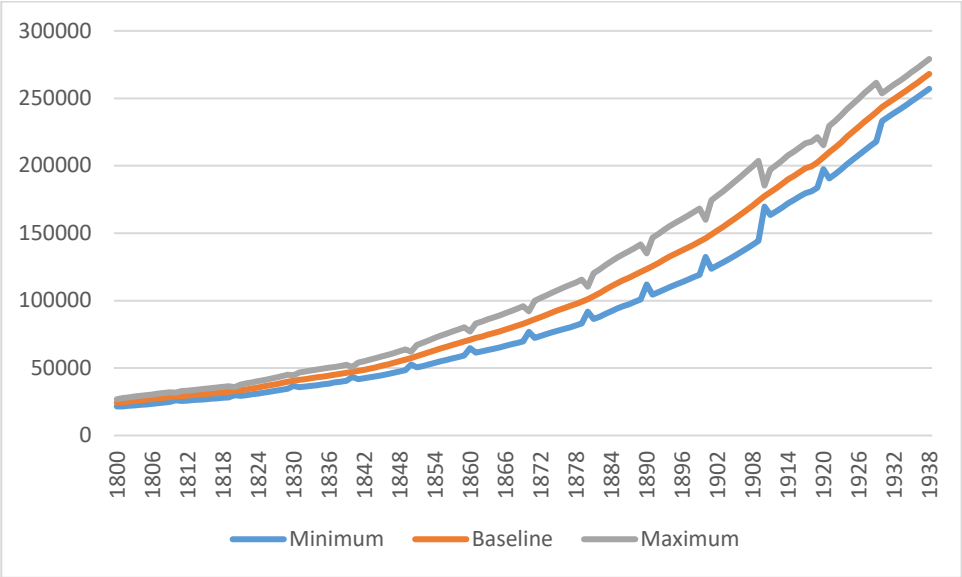
Given the interval of confidence, the potential error depends on the size of population of each area (Figure 15)

Figure 15
Errors in estimates (thousands)

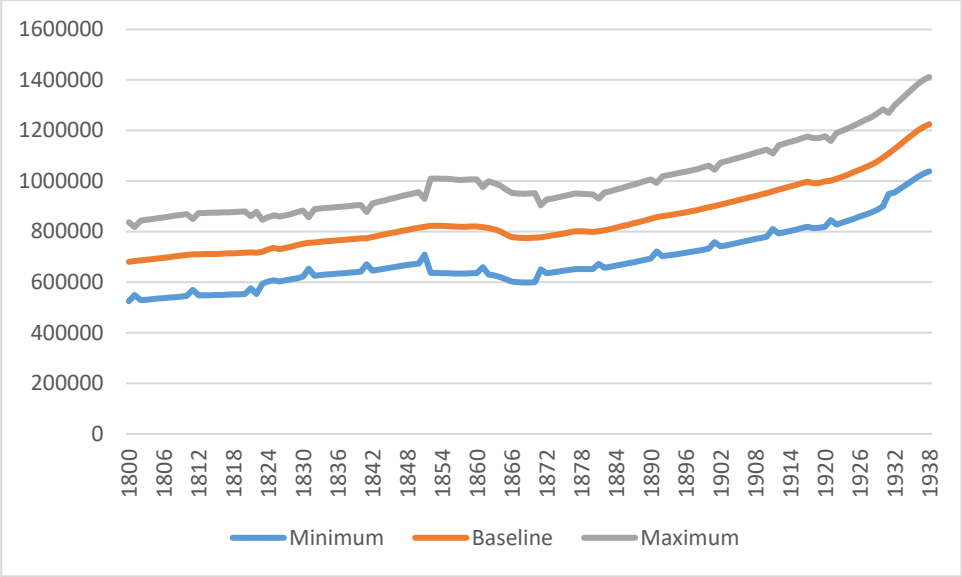
a) Africa



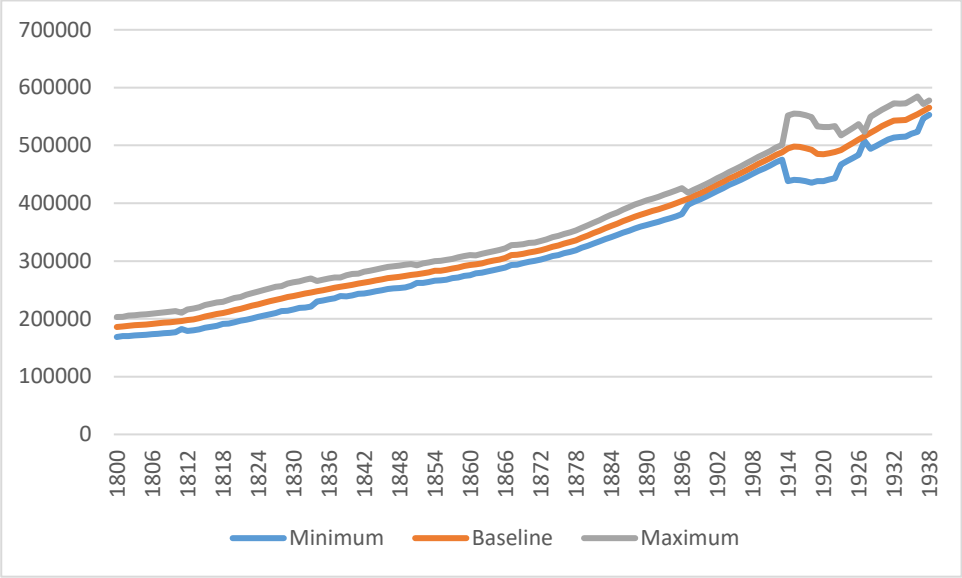
b) Americas



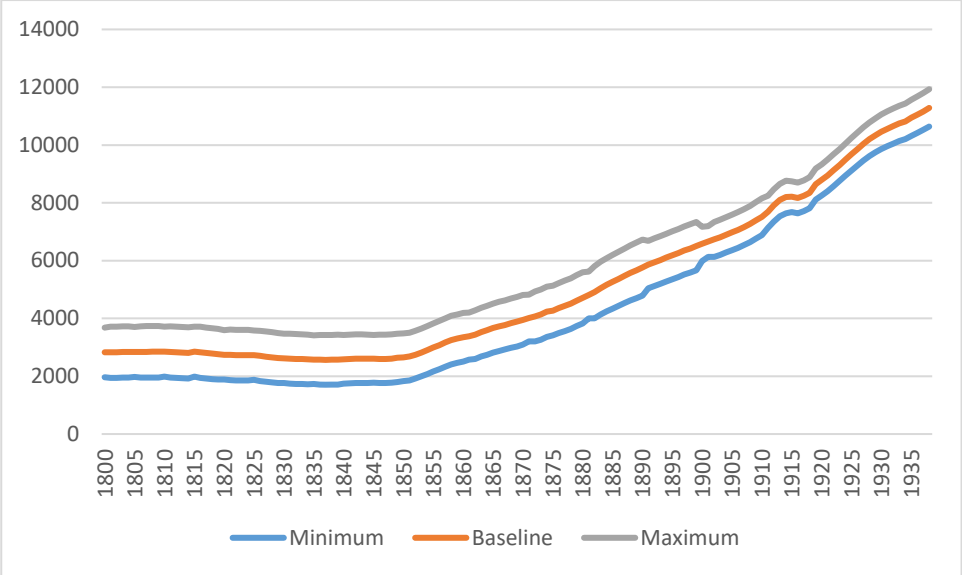
c) Asia



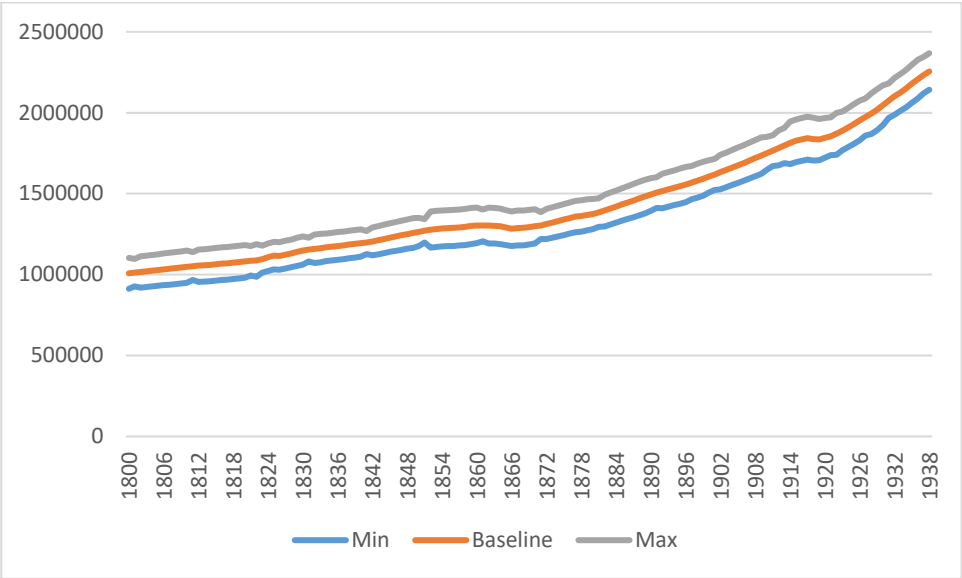
d) Europe



e) Oceania



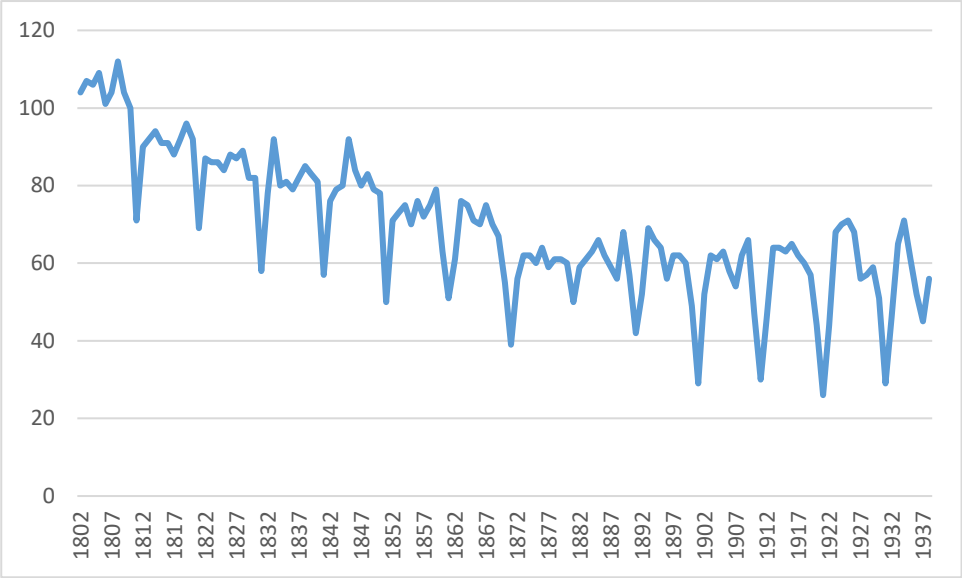
f) World



The figures highlight some continent-specific features, such as the long-term reduction of errors in Oceania, the bulge in Europe in the second half of the 1910s and 1920s and the systematic shrinking of the band in the Americas in census years. World-wide, the modest reduction in confidence interval is compensated by the increase in total population, so that the corresponding margin of error of the aggregate estimate fluctuates around 200 million people, with a minimum of 141 million in 1841, a census year, and a maximum of 265 in 1917. It is possible to compute, given the yearly band, the greatest possible error in long-term trends as the differences between the lower (upper) bound in 1800 and the upper (lower) bound in 1938. They are substantial, but do not change the historical narrative. Our baseline estimate yields a 123.7 % increase in world population, from 1008 to 2254 million, while the alternatives range from a minimum of 94.1% (1103 to 2142) to a maximum of 159.5% (from 912 to 2367 million).

8.3 We have been forced to estimate population with linear interpolation in about half of observations (9157 out of 21509 testable cases) [43].

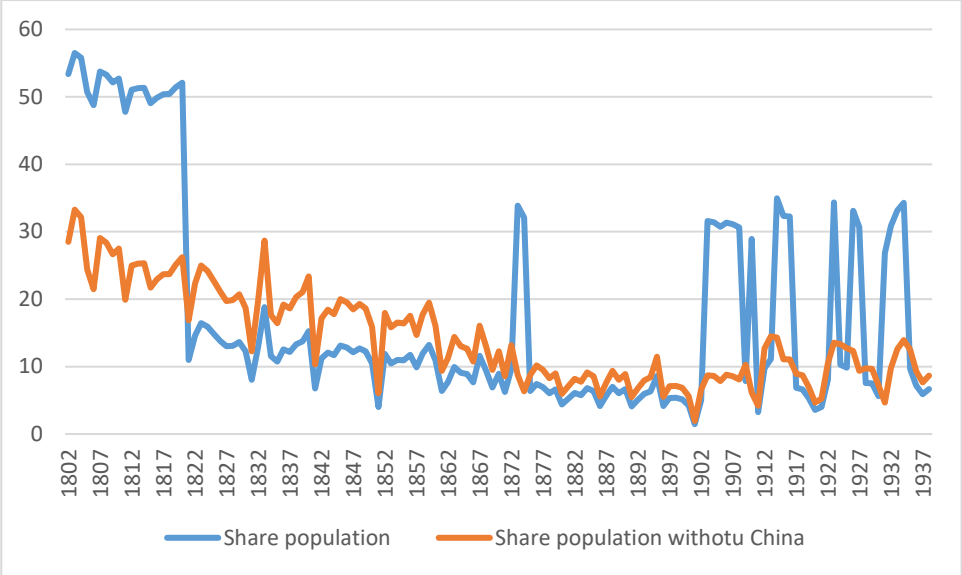
Figure 16
Number of polities with linearly interpolate population



The distribution in time shows the expected (downward) spikes in the census years, which often correspond to change from one rate of interpolation to another, and a sizeable decline in the first decades of the 19th century. Since the 1870s, the yearly number of observations in non-census years remains stable around 60 – i.e. about a half. Most of these observations refers to African or Middle Eastern polities, with small population. Indeed, the share of world population estimated with linear interpolation is much lower (Figure 17)

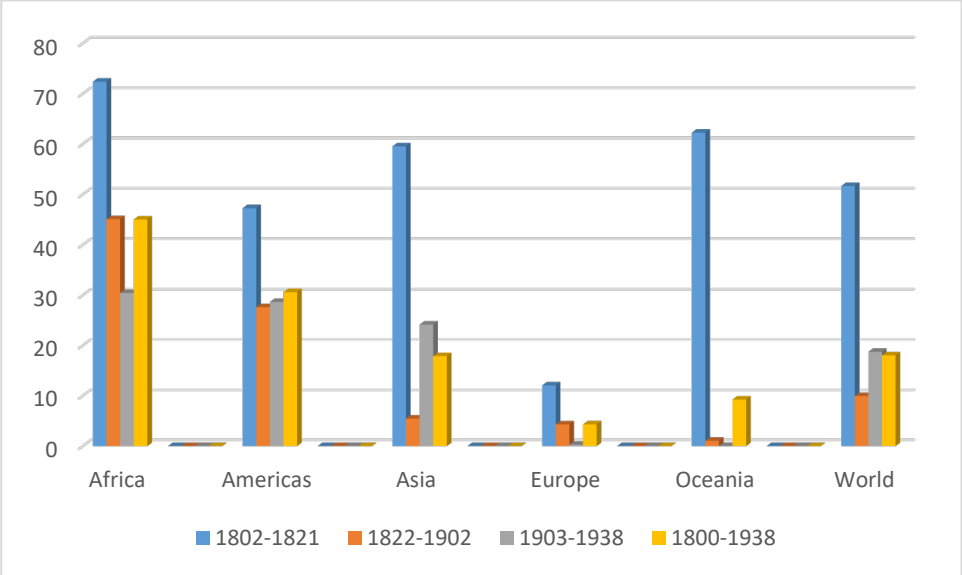
Figure 17
Share of population estimate with linear Interpolations

[43] We compute this figure as sum of all consecutive years with equal change, including cases of no change, which usually are outcome of assumption as well. We lose the two initial observations of each series and therefore the number of cases is lower the number of population estimates.



The share is substantially lower across the whole period (18% vs 43%) and much lower from 1821 to 1902 (10% vs 44% for number of polities). It increases again later, almost exclusively because the series for China shows same rate of growth for two or more years, without necessarily being linearly interpolated. The data by continent (Figure 18) confirm the key role of Asia in determining the world changes

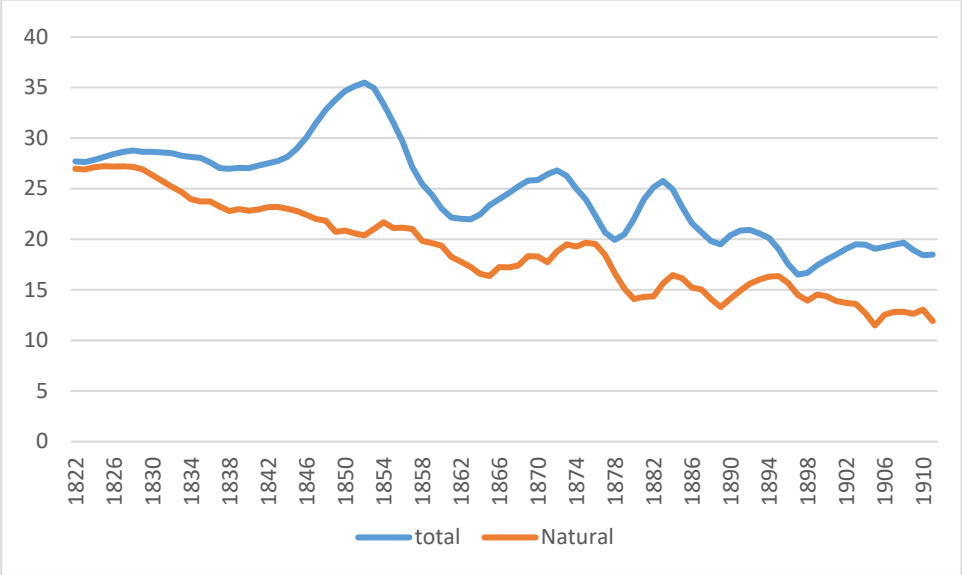
Figure 18
Linear interpolations as share of population, by continent



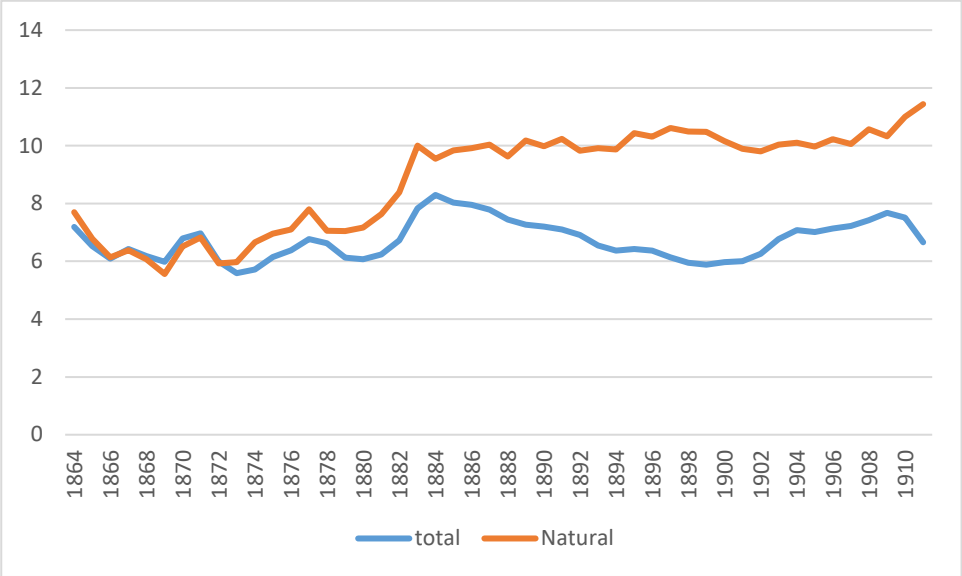
8.4 Figure 19 shows the extent of potential bias from the omission of migrations by comparing total and natural population growth in the largest immigration and largest immigration country in the age of mass migrations (Hatton and Williamson 1998)

Figure 19
Natural and total population increase, per thousands, five years averages

a) United States



b) Italy



Sources: United States population Federico Tena data-base natural increase United States estimated as a residual, deducting the net immigration (Historical statistics series Aa13) Italy ISTAT on line table 2.3

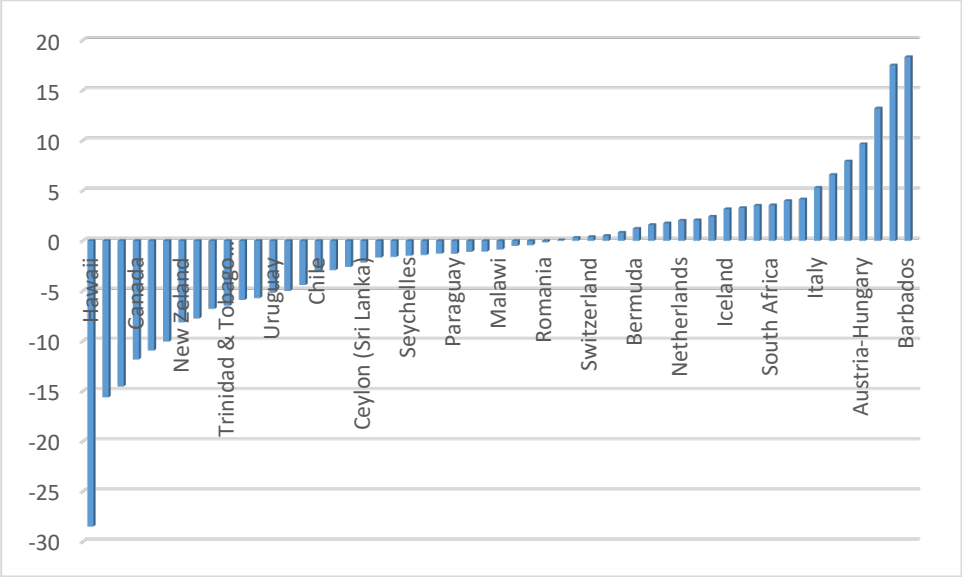
As expected our series of total population underestimates the natural increase (and thus the extent of the first stage of the demographic transition) in Italy and overestimates it in the United States. The biases are substantial: at the peak the difference is half percentage point increase in Italy (population 5.8 vs natural 10.5 in 1896-1900) and one a half in the United States (20.4 natural vs 35.5 total in 1850-1854). However, they are not sufficiently large to change the overall picture of the on-going transition in both countries, with high but declining rates of natural increase in the United States and fairly high rates in Italy

We extend the analysis to other countries by building a data-base of rates of natural increase with two different methods. When possible, we get directly data on birth and death rates from sources such as Mitchell' s International Historical statistics and Rothenbacher (2002 and 2013). When these latter are not available, we compute rates as total growth less net immigration (Ferenczi Willcox 1929). Overall, we have been able to muster long series for most advanced countries (but also for some less developed ones, such as Chile since 1850) and snapshots for quite a few other ones for a total of 81 polities [44]. We plot differences total and natural increase of population in 1908-1913, the peak of mass migrations and 1920-1924 and 1934-38, the years of most extensive country coverage (Figure 20)

Figure 20

Average difference between total to natural increase

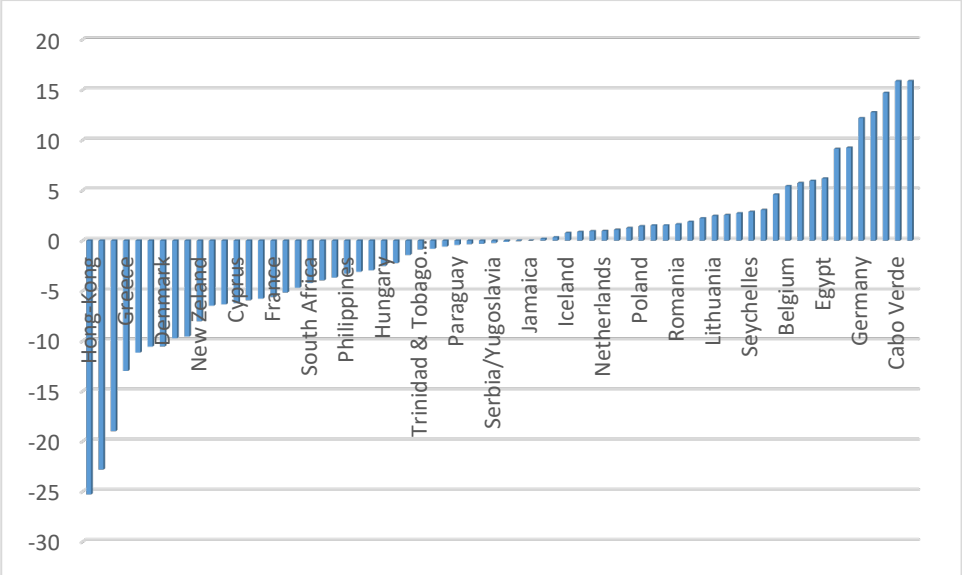
a) 1908-1913 (58 polities)[45]



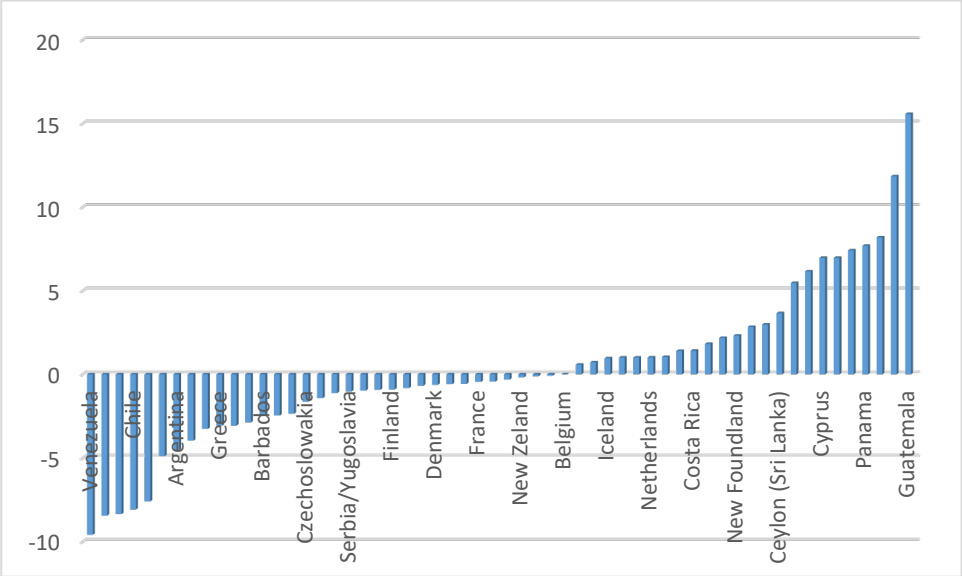
b) 1920-1924 (68 polities)

[44] We have been able to collect 3286 rates from direct sources and estimate an additional 749 with from the indirect computations. They account for 9% or potential observations in 1801-1869, 24% 1870-1913 and 34% 1914-1938

[45] For the sake of readability of the figure, we omit Hong-Kong (-100.5) Basutoland (+ 369.4) and Swaziland (+73.5). These two latter are rather suspicious, as the estimate of total population refers to the whole Southern Africa, disregarding the specific situation of these two enclaves in South Africa.



c) 1934-1938 (71 polities)



There are some cases of quite large differences, but their share on world population is low (Table 9)

Table 9
Aggregate biases from migration

	% covered	Shares on covered Mild (± 2‰)	Substantial (± 5‰)	Large (± 10‰)
1908-1913	49.6	77.3	22.6	3.1
1920-1924	51.4	79.7	24.5	13.8
1934-1938	57.2	60.3	17.6	0.0

9) Conclusions

This work has confirmed the broad outline from Maddison (and others). The world population did grow in the long run and the growth accelerated in the early 20th century, as an harbinger of the post war population boom. The lowest absolute yearly increase (1.05% in 2019-2020) was exceeded only in the second half of the 1920s and in the 1930s, with an average rate around 1.1%.

The yearly data, albeit imperfect, offer two relevant additional results. First, world was still plagued by crises – both short shocks and longer trends… Some of these crises claimed high proportion of the affected areas. Especially devastating the (admittedly poorly measured) decline at collapse and slave trade. However, most crises had limited impact on the growth of world population. There were two exceptions, the late 1910s one, with World War One, Spanish flu and Russian revolution and the Tai'ping war. Both reduced significantly the growth rate, but the impact of the latter was much stronger. The pre-WWII world thus differed substantially from the post-WWII world, when local crises were rare and less severe and world population kept on growing..

Second we have got some insights on the transition. By 1938, the transition completed or very advanced in high income countries, while in the periphery the record seems mixed. In some cases, transition was just starting, in others it had begun earlier but the process protracted in a slow/motion timing. To same extent the pattern reflected exogenous events.

Last but not least, we have to repeat that our series are imperfect. It seem unlikely that they could be significantly improved by the discovery of new official sources – historical demographers have done quite a good job. In some cases, the series might be improved by systematic work on micro-data, such as parish registers. Where not available, possible to use archeological sources – but it seems very unlikely that we will

References

Aird John S. (1968) 'Population growth' in Eckstein Alexandr Walter Galenson and Ta-ching Liu (eds) *Economic trends in communist China* Edinburgh UP 1968 pp.183-327

Alter George and Gregory Clark (2010) 'The demographic transition and human capital' in Stephen Broadberry and Kevin O'Rourke (eds) *The Cambridge Economic History of Modern Europe. Vol I: 1700-1870* Cambridge: Cambridge University Press 2010 pp.44-69

Annuaire Statistique

Athukorala Prema-Chandra and Chaturica Athukorala (2020) The Great Influenza Pandemic of 1918-20: an interpretative survey at the time of covid-19 Centre for economic history the Australian National University Discussion paper series 2020-09 October 2020

Baffour Bernard, Thomas King and Paolo Valente (2013) 'The Modern Census: Evolution, Examples and Evaluation' *International Statistical Review / Revue Internationale de Statistique,* 81, pp. 407-425

Beach Brian, Karen Clay and Martin Saavedra (forthcoming) 'The 1918 influenza pandemic and its lessons for COVID 19' *Journal of economic perspectives*

Bennett M.K. (1954) *The world's food: a Study of the World Population, National Diets, and Food Potentials* Harper and Brothers New York

Becker Jean-Jacques (1999) Les deux guerres mondiales et leur consequences in Jean-Pierre Bardet and Jacques Dupâquier (eds.) *Histoire des populations de l'Europe* Fayard Paris Vol II pp. 73-92

Boomgaard Peter and A.J. Gooszen (1991) *Population trends 1795-1942 Changing economy in Indonesia* vol 11 Amsterdam Royal tropical institute The Netherlands

Burgess Robin and Dave Donaldson (2010) **'**Can openness mitigate the effect of weather shocks? Evidence from India's famine era' *American Economic Review* 100 (May 2010) pp.449-453

Bushnell Andrew (1993) The "Horror" reconsidered: an evaluation of the historical evidence for population decline in Hawai'i, 1778-1803' *Pacific studies* 16 pp. 115-161

Biraben, J.-N., An essay concerning mankind's evolution. Population, Selected papers. 1980.

Caldwell John and Thomas Schindlmayr (2002) 'Historical population: unraveling the consensus' *Population and development review* 28 pp.183-204

Campbell I.C. (2006) 'More Celebrated than Read: The Work of Norma McArthur' in Doug Munro, Brij V. Lal (eds.) *Texts and Contexts. Reflections in Pacific Islands Historiography* Honolulu: University of Hawai'I Press 2006 pp.98-110

Carr Saunders, A.M. (1936) *World population. Past population and present trends* Oxford: Clarendon Press

Carreira Antonio (1985) *Demografia Caboverdeana* Cabo Verde: Edição do instituto Caboverdaeno de libro

Cervellati Matteo and Uwe Sunde (2011) 'Life expectancy and economic growth: the role of the demographic transition' *Journal of economic growth* 16 pp. 99-113.

Chapman, Jonathan (2019) 'The contribution of infrastructure investment to Britain's urban mortality decline, 1861-1900' *Economic history review* 72 (1) pp.233-259

Chaudhary, Latika and Peter Lindert (2021) 'Healthy, Literate, and Smart: The Global Increase in Human Capital' in Stephen Broadberry and Kyoij Fukao (eds) *Cambridge Economic History of Modern World vol II 1870 to present* Cambridge: Cambridge University Press 2021 pp. 329-355

Cheng K.F. and P.C. Leung (2007) 'What happened in China during the 1918 influenza pandemic?' *International journal of infectious diseases* 11 (2007) pp.360-364

Chesnais Jean-Claude (1992) *The demographic transition* Oxford: Clarendon Press

Clark Colin (1967) *Population growth and land use* New York:Mac Millan

Coale Ansley J. and Norfleet W. Rives (1973) **'**A statistical reconstruction of the black population of the United States 1880-1970' *Population Index* 39 pp. 3-36

Coale Ansley and Melvin Zelnik (1963) *New estimates of fertility and population in the United States* Princeton: Princeton University Press

Collver Andrew O. (1965) *Birth rates in Latin America* Institute of International studies, UC Berkeley, Berkeley

Davenport Romola and Osamu Saito (2021) 'Population and Human Development since 1700' in Stephen Broadberry and Kyoij Fukao (eds) *Cambridge Economic History of Modern World vol I 1700-1870* Cambridge: Cambridge University Press pp. 289-311

Davis Kingsley (1968) *The population of India and Pakistan* New York: Russel & Russel 2nd ed

Delventhal, Matthew Jesús Fernández-Villaverde and Nezih Guner (2021) *Demographic Transitions Across Time and Space* CEPR discussion papers 16078 November

Durand, J.D. (1974) 'Historical estimates of world population: An evaluation', Population Studies Center, Philidelphia.

Durand, J.D. (1977) 'Historical estimates of world population' *Population and Development Review*, 3 pp. 253-296

Etemad Bouda (2007) *Possessing the world. Taking the measurement of colonization from the 18th to the 20th century* New York and Oxford: Berghahn books [French ed. 2000]

Feinstein, Ch. H. and M. Thomas, (2002) 'A Plea for Errors' *Historical methods* 35 pp. 155-165

Ferenczi Imre and Walter Willcox (1929) *International migrations Vol I Statistics* NBER

Frankema Ewout and Morten Jerven (2014) 'Writing history backwards or sideways: towards a consensus on African population, 1850-2010' *Economic history review* 67 pp.907-931

Galloway Patrick R. (1994) 'A reconstruction of the population of North Italy from 1650 to 1881 using annual inverse projections with comparisons to England, France and Sweden' *European journal of population* 10 pp.223-274

Guinnane Timothy (2011) 'The historical fertility transition: a guide for economists'*Journal Economic Literature* 49 pp. 589-614

Guinnane Timothy (2021) 'We Do Not Know the Population of Every Country in the World for the past Two Thousand Years' CESIFO Working paper 9242 August 2021

Henry Louis and Yves Blayo (1975) 'La population de la France de 1740 a 1860' *Population*, Vol. 30 pp. 71-122

Historical statistics United States (2006) Carter, S.B. Gartner, S.S., Haines, M.R., Olmstead, A. Sutch, R. and Wright, G. (eds.) *Historical statistics of the United States. Millennium edition*. New York: Cambridge University Press

ISTAT on line Serie storiche https://www4.istat.it/it/prodotti/banche-dati/serie-storiche (accessed July 2021)

Haines Michael (2000) 'The white population of the United States, 1790-1920' in Michael Haines and Richard H. Steckel (eds.) *A population history of North America* Cambridge: Cambridge University Press pp.305-371

Hamilton, J. D. (2018) 'Why you should never use the Hodrick-Prescott filter', *Review of Economics and Statistics*, 100(5), pp. 831-843.

Hatton Timothy and Jeffrey G. Williamson (1998) *The age of mass migration*

Oxford: Oxford University Press

Haub, C., How many people have ever lived on Earth ? Population Today, February: p5, 1995.

Ho Ping-ti (1959) *Studies on the population of China* Cambridge (Mass.):Harvard University Press

Johnson, Niall P.A.S. and Juergen Mueller (2002) 'Updating the accounts: global mortality of the 1918-1920 'Spanish' influenza pandemic' *Bulletin of the history of medicine* 76 (2002) pp. 105-115

Kapitsa S.P. 'The phenomenological theory of world population growth' Physics Uspekhi 1996 39: 57-71

Karpat Keman (1985) *Ottoman population 1830-1914* Madison: University of Wisconsin Press

Kim Khoo Kay (1998) 'Malaysia: immigration and the growth of a plural society' *Journal of the Malaysian Branch of the Royal Asiatic Society* Vol. 71 pp. 1-25

Kirby 1996

Kirch Patrick (2007) "Like Shoals of Fish" Archaeology and Population in Pre-Contact Hawai'i' in Patrick Kirch and Jean Louis Rallu (eds.) *The growth and collapse of Pacific island societies. Archaelogical and demographic perspectives* Honolulu: University of Hawai'i Press pp. 53-69

Kirch Patrick and Jean Louis Rallu (2007) 'Long term demographic evolution in the Pacific islands' in Patrick Kirch and Jean Louis Rallu (eds.) *The growth and collapse of Pacific island societies. Archaelogical and demographic perspectives* Honolulu: University of Hawai'i Press pp.1-15

Klein Goldewijk, C.G.M. and Battjes, J.J., (1995) *The IMAGE Hundred Year (1890-1990) Data Base of the Global Environment (HYDE)*. Report Nr. 482523001, Bilthoven. 1995.

Klein Goldewijk, K. , A. Beusen, M. de Vos and G. van Drecht (2011). The HYDE 3.1 spatially explicit database of human induced land use change over the past 12,000 years, *Global Ecology and Biogeography***20(1)**: 73-86. DOI: 10.1111/j.1466-8238.2010.00587.x.

Klein Goldewijk, K. , A. Beusen, and P. Janssen (2010). Long term dynamic modeling of global population and built-up area in a spatially explicit way, HYDE 3 .1. *The Holocene***20(4)**:565-573. http://dx.doi.org/10.1177/0959683609356587

Korenjak Martin (2018) 'Humanist demography: Giovanni Battista Riccioli on the world population' *Journal of the early modern studies* 7, pp.73-104

Kuczynski Robert Rene (1937) *Colonial population*, London: Oxford University Press on behalf ot the Royal institute of International Affairs.

Kuczynski Robert Rene (1948-1953) *Demographic survey of the British colonial empire* Oxford: Oxford University Press 3 vols

Statistical Yearbook League of Nations available on line at https://wayback.archive-it.org/6321/20160901220258/http://digital.library.northwestern.edu/league/otcgi/digilib/llscgi60-ae97.html 1926 – 1944. (accessed April 2019)

Lee, Ronald (2003) 'The Demographic Transition: Three Centuries of Fundamental Change' *Journal of economic perspectives* 174(4) pp.167-190

Lutz Wolfgang and Anne Babette Wils (1994) 'People on Mauritius: 1638-1991' in Wolfgang Lutz (ed.) *Population-development-environment. Understanding their interactions in Mauritius* Berlin:Springer Verlag pp. 74-97

Maddison Angus 1995

Maddison Angus 2010

Manning Patrick (1988) 'The impact of slave trade exports on the population of the Western Coast of Africa, 1700-1850' In Daget Serge (ed) *De la traite à l'esclavage.* Nantes:Centre de recherche sur l'histoire du mond atlantique pp. 111- 134

Manning Patrick (2010) 'African population. Projections 1850-1960' in Ittmann Karl, Dennis D. Cordell and Gregory H. Maddox (eds.) *The demographics of empire*. Athens: Ohio University Press pp. 245-275

Manning Patrick (2014) 'African population, 1650-2000: comparisons and implications of new estimates' in Emmanuel Akyeampong, Robert Bates, Nathan Nunn and James Robinson (eds) *Africa's development in historical perspective* Cambridge: Cambrideg University Press pp.131-150

Manning Patrick and Scott Nickleach (2014) 'African Population, 1650-1950: The Eras of Enslavement and Colonial Rule' Unpublished manuscript dataverse.harvard.edu/dataverse/ WH_AfricanPopMigration (downloaded June 2021)

Markevich Andrei and Mark Harrison (2011) 'Great War, civil war and recovery: Russia's national income, 1913 to 1928' *Journal of Economic History* 71 pp.672-703

McArthur Norma (1968) *Island populations of the Pacific* Canberra: Australian National University Press

McEvedy, C. and Jones, R. (1978) *Atlas of World Population History*, Middlesex, England: Viking Penguin.

Merrick, T.W., World population in transition. Population Bulletin, 41(2): 53. 1986. /C/

Murtin Fabrice (2013) 'Long-term determinants of the demographic transition, 1870-2000' *Review of Economics and Statistics* 95 pp.617-631

Nordyke Eleanor C. (1989) *The peopling of Hawai'I* Honolulu: University of Hawai'i press [2nd ed]

International historical statistics Mitchell, B.R *International Historical Statistics; Africa, Asia and Oceania 1750-2005* Mitchell, B.R. (2007, 2013): *International Historical Statistics; Africa, Asia and Oceania 1750-2005*. Sixth Edition. Palgrave Macmillan, New York. *International Historical Statistics 1750-2005: Americas*. Palgrave Macmillan, New York. *International Historical Statistics 1750-2005: Europe*. Palgrave Macmillan, New York. (2013)

O'Grada Cormac and Jean-Michel Chevet (2002) 'Famine and market in Ancien Régime France' *Journal of Economic History* 62 pp.706-733

Parkerson Donald H (1991) 'Comments on the under-enumeration of the U.S. Census, 1850-1880 *Social science history* 15 pp.509- 515

Perrin Francoise (forthcoming) 'On the origins of the demographic transition: rethinking the European marriage pattern' *Cliometrica*

Pfister Ulrich and Georg Fertig 'The population history of Germany: research strategy and preliminary results' MPIDR WP 2010-035 (December 2010)

Platt Stephen R. (2012) *Autumn in the Heavenly Kingdom. China the West and the epic story of the Taiping civil war*, New York: A.Knopf

Poulain, Michel and Anne Herm (2013) 'Central Population Registers as a Source of Demographic Statistics in Europe' *Population* 68, pp. 183 212

Razzaque, Mohammad, Philip Osafa-Kwaako and Roman Grynberg (2007) 'The problems of commodity dependence' In Roman Grynberg and Samantha Newton (eds) *Commodity prices and development* Oxford University Press Oxford pp. 7-16

Rothenbacher Franz (2002) *The European population* Palgrave Basingstoke

Rothenbacher Franz (2012) *The Central and East European Population Since 1850* Basingstoke: Palgrave Macmillan

Schmitt Robert (1972) 'New estimates of the pre-censal population on Hawaii' *Journal of the Polynesian society* 80 pp. 237-243

Shryock, Henry, Jacob Siegel and associates (1971) *The methods and materials of demography* Washington US Department of commerce

Smith, Leonard Robert (1980) *The Aboriginal Population of Australia* s, Canberra: Australian National University Pres

Spreeunwenberg, Peter, Madelon Kroneman and John Paget (2018) 'Reassessing the global mortality burden of the 1918 influenza pandemic' *American journal of epidemiology* 187 n.2 pp.2561-2567

Steckel Richard (1991) 'The Quality of Census Data for Historical Inquiry: A Research Agenda' *Social science history* 15 pp.579-599

Stannard David E. (1989) *Before the horror* Social science research institute Honolulu: University of Hawai'i

Stern, D.I. and Kaufmann, R.K., Estimates of global anthropogenic sulphate emissions 1860 - 1993. Center for Energy and Environmental Studies, Boston University, Working paper series 9602. 1996.**Chemosphere** 33

Swaroop S (1951) 'Growth of the population in the world' *WHO Epidemiological and vital statistics report* IV n.4 pp.162-169

Thornton, Russel (2000) 'Population history of native North Americans' in Haines Michael and Richard H. Steckel (eds.) *A population history of North America* Cambridge: Cambridge University Press pp.9-50

Thornton Russell and Joan Marsh-Thornton (1981) 'Estimating Prehistoric American Indian Population Size For United States Area: Implications of the Nineteenth Century Population Decline and Nadir' *American Journal of Physical Anthropology* 55 pp. 47-53 (1981)

Schmitt Robert (1972) 'New estimates of the pre-censal population on Hawaii' *Journal of the Polynesian society* 80 pp. 237-243

Smith, Leonard Robert (1980), *The Aboriginal Population of Australia*, Australian National University Press, Canberra

Shryock, Henry, Jacob Siegel and associates (1971) The methods and materials of demography Washington: US Department of commerce

Spagnoli, Paul G.(1977) 'Population History from Parish Monographs: The Problem of Local Demographic Variations' *Journal of Interdisciplinary History*, 7 pp. 427-452

Spreeunwenberg, Peter, Madelon Kroneman and John Paget (2018) 'Reassessing the global mortality burden of the 1918 influenza pandemic *American journal of epidemiology* 187 pp.2561-2567

Statisches Jahrbuch Deutsche Reich 1938

Swaroop S. (1951) 'Growth of the population in the world' *WHO Epidemiological and vital statistics report* IV n.4 (April) pp.162-169

Thorvaldsen Gunnar (2018) *Censuses and Census Takers A Global History* Abingdon: Routledge

Tuve, G.L., Energy, environment, population, and food. A Wiley-Interscience Publication. John Wiley & Sons, New York, 264 pp. 1976.

United Nations 1973 The determinants and consequences of population trends Population studies, 50 p.10

United Nations (1999) *The world at six billions* New York: United nations

United Nations (2019) Population Division Department of Economic and Social Affairs *World Population Prospects: The 2019 Revision* POP/DB/WPP/Rev.2019/POP/F01-1 (accessed August 20 2021)

Van der Vleuten. Lotte and Jan Kok (2014) 'Demographic trends since 1820' in Jan Luiten Van Zanden et al (ed) *How was life? Global well-being since 1820*, Paris: OECD pp.37-55

Wilke Jurgen (2004) 'From parish register to the ''historical table'': The Prussian population statistics in the 17th and 18th centuries', *History of the Family*, 9 pp. 63–79

Willcox Walter (1940) *Studies in American demography* Ithaca NY Cornell University Press

Woytinsky, W.S. and Woytinsky, E.S., World population and production, The Lord Baltimore Press, New York. 1953.

Wrigley Edward Anthony and Roger Schofield (1989) *The population history of England 1541-1871: a reconstruction*. Cambridge: Cambridge University Press

Yáñez César, Rodrigo Rivero, Marc Badia-Mirò & Anna Carreras Marín (2012). La Población de los países latinoamericanos desde el siglo XX hasta 2008. Ensayo de Historia Cuantitativa. GHIP Working Paper n 17