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# Demographic Metabolism at Work

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Exactly half a century ago, Norman Ryder published his influential paper on "The Cohort as a Concept in the Study of Social Change" in the American Sociological Review (Ryder 1965). In this paper, which has become a standard reference on the origins of cohort analysis, he introduces, among other topics, the concept of "Demographic Metabolism" which he uses to describe the massive process of personnel replacement driven by births, lives and deaths of individuals (Ryder 1965, p.843). This concept is placed right at the intersection of individual level and aggregate level perspectives on change: While individuals succumb, societies become immortal, if reproduction is sufficient to offset mortality. Ryder combines this thought with the assumption that the individual's flexibility to change is restricted once certain characteristics or attitudes are established. Consequently, he viewed the continuous emergence of new participants in the social process and the withdrawal of their foregoers as the main force of social transformation.

Despite the fact that Ryder's 1965 article already provides most of the necessary conceptual elements of a formal theory of social change with predictive power, such a theory had not yet been explicitly developed. In fact, the whole concept of demographic metabolism has not received much attention until recently, when combination with the powerful analytical

tools of multi-dimensional (multi-state) demography – developed in the 1970s – facilitated its operationalization and the calculation of actual forecasts based on the demographic metabolism (Lutz 2013). In his article entitled "Demographic metabolism: A predictive theory of socioeconomic change", Lutz presents a consistent theoretical framework – including both intra-cohort transitions and inter-cohort changes, thus enlarging Ryder's original framework – and puts it to work in terms of actual numerical projections of the changing composition of populations that are sub-divided according to clearly defined, observable sources of population heterogeneity. This approach has already been successfully applied to the reconstruction and projection of the changing composition of populations by age, sex and different levels of educational attainment for all countries in the world (Lutz and KC 2011, Lutz et al OUP) and it has also been used for projecting the "soft" characteristic of European identity within EU member countries (Lutz et al 2006). Yet, this powerful approach is not yet widely known and recognized in the broader social science community. The main purpose of this article therefore is to review and demonstrate the enormous potentials of the demographic metabolism approach for capturing and forecasting social change, exactly half a century after it had been first introduced.

This paper will start with a review of the theoretical foundations of the theory of demographic metabolism as given by Lutz (2013) and Lutz (2015). Next, we will highlight the application of this approach to the systematic reconstruction and projection of population projections by age, sex and highest level of educational attainment. Following this review section, the paper includes two entirely new aspects. First, the above-mentioned projections of the spread of European identity out to 2030, which were based on Eurobarometer data from 1996 to 2004, will be assessed and checked against the actual developments as documented by

the 2013 wave of the Eurobarometer. Since the original data stem from before the recent economic and political crisis in the European Union, this can be seen as a validation exercise of the predictive value of this model in stormy times that had not been foreseen a few years earlier.. Secondly, the approach is being applied to an entirely new topic, namely the question of the extent to which attitudes towards homosexuality in different countries of the world change from one cohort to the next. Based on this assessment, the paper will apply the demographic metabolism model to derive projections of the future prevalence of tolerance towards homosexuality in Japan, Spain and the US to 2040. The paper will conclude with a brief critical discussion and give an outlook to possible other fields of application of the presented approach.

## Karl Mannheim and Norman Ryder

The idea that societies change as new generations "take over" is already found in early writings on this topic by pre-Socratic philosophers and in Confucian philosophy, albeit in rather general and vague form. It is all the more surprising that such a plausible concept, which reflects everyday life experiences in most families, companies and institutions across all cultures and times, has so far inspired little systematic scientific effort to formally and comprehensively describe this important force of social change. This applies both to the systematic analysis of historical evolutions and to taking inter-cohort change as the basis for forecasting.

In historical perspective, the strain of thought that comes closest to the idea of viewing social change as being driven by the succession of generations, is to be found in the writings of art historians in the late 19$^{th}$ and early 20$^{th}$ centuries who explain the sequence of different

historical epochs as being a consequence of the replacement of older generations of artists through new ones with new views of the world, new priorities and new styles of producing art (Ref.). The sociologist Karl Mannheim was one of the first to offer a comprehensive synthesis of this view of history. In his essay on "The Problem of Generations" (first published in German in 1927 and translated to English in 1952), Mannheim describes two opposing views on generations: The first one is referred to as the "biological" or "positivist" perspective, as it deals with aspects of generations that are measurable, such as the average periods of time taken for the older generation to be replaced by the new one in public life (Mannheim 1927, p. 278). This perspective can safely be interpreted as demographic. The other approach, which he calls "romantic-historical", is clearly associated with the writings of the German historian Dilthey and is non-quantitative in scope. There the central notion is "entelechy" or the expression of the "inner aim" of a generation which is synonymous with its "inborn way of experiencing life and the world" (Mannheim 1927, p. 283). Mannheim seemed to be more in favor of the first view, but in applying it, he focused only at the past, trying to understand the forces shaping history, rather than looking into the future.

Examining the forces behind the generation units and the conditions under which a new group of people growing up becomes sufficiently different from the previous one in order to be called a new generation, Mannheim defined a generation as being determined by its "social location" (German: soziale Lagerung), which is being shared by all members of a generation. In fact, he compares it to the way one is a member of a specific social class, but viewed over time rather than cross-sectionally. In this view, generation and class have in common that both "endow the individuals sharing in them with a common location in the social and historical process, and thereby limit them to a specific range of potential experience, predisposing them

for a certain characteristic mode of thought and experience, and a characteristic type of historically relevant action". (Mannheim 1927, p. 291). This is where the more formal cohort approach of contemporary demography, under which inner values (entelechy) may be a consequence but never a defining criterion for membership in a generation, is very different from Mannheim's approach, which is still to certain degree trying to capture the qualitative inner spirit of a generation.

More than a generation after Mannheim, the Canadian-American demographer Norman Ryder took up the topic from a more demographic perspective. His essay on "The Cohort as a Concept in the Study of Social Change" was published in ASR in 1965, but he mentions in a footnote that an earlier version of the paper was already presented in 1959. Some of these thoughts are also included in his 1980 book "The cohort approach" (Ryder 1980). Ryder starts from the central, but (then and now) rarely used notion of "demographic metabolism", which he defines as the "massive process of personnel replacement" driven by the births, lives and deaths of individuals (Ryder 1965, p.843). While he saw the flexibility for individuals to change over their life time as limited, the appearance of new individuals in the social process provide an opportunity for social transformation: "the continual emergence of new participants in the social process and the continual withdrawal of their predecessors compensate the society for limited individual flexibility" (Ryder 1965, p.844). Based on the assumed inflexibility of individuals over their lifetimes, Ryder arrives at the strong statement that "The society whose members were immortal would resemble a stagnant pond" (Ryder 1965, p.844). An important additional thought of his was, that the "metabolism may make change likely, or at least possible, but it does not guarantee that the change is beneficial." (p.844). Hence, this is not

necessary an approach to describe social progress but more neutrally social change that may go in any direction.

Ryder defined a cohort in what has since become the standard textbook definition: "A cohort may be defined as the aggregate of individuals (within some population definition) who experienced the same event within the same interval" (p.845). In most applications, birth is taken as the defining event, but it could also be marriage or any other clearly identifiable life cycle event. The decisive step in which Lutz went beyond Ryder was to relax the assumption of strong cohort determinism. The below described tools of multi-dimensional population dynamics also allow for changes to happen over the life course of cohorts. Hence, the possibility of lifelong learning and changes within birth cohorts can in itself present a force of socioeconomic change, such that immortality would no longer necessarily result in Ryder's "stagnant pond". To what degree cohort effects dominate over age and period effects depends on the specific characteristic studied. In some cases (e.g. highest educational attainment after a certain age) the characteristic is sticky by definition, in other cases (such as the examples to be used later in the text of European identity or attitudes toward homosexuality) this is a matter of empirical analysis for the past and corresponding assumptions for the future.

## Basic Premises of the Theory of "Demographic Metabolism"

The theory of demographic metabolism as specified by Lutz (2013) is a macro-level theory that predicts aggregate-level change rather than individual behavior. It focuses on the changing composition of a population according to certain critical characteristics which individuals can carry. Secondly, it can be called a "demographic" theory of socioeconomic change, in so far as

it was inspired by developments within the field of demography, particularly multi-dimensional cohort component analysis (e.g. Rogers, Keyfitz, Ref.). However, its application is not limited to demographic questions. Rather, the main goal is to predict social change with regard to a wide range of different relevant dimensions, ranging from values and attitudes to aggregate-level behaviors, skills and productivity of the labor force. Thus, the theory only uses a demographic paradigm, but it is not primarily intended to explain and forecast demographic variables (such as population size, birth and death rates, migration, etc.).

In more formalized language, the four basic propositions of the theory have been defined as follows: (Proposition1): People are the primary building blocks of every society. Hence, they must form the basic elements of any theory of social change. Comment: Modern brain research might object that we have to go even deeper, sort of to the "sub-atomic" level of society, and to study human decision making as the result of complex interactions among different parts of our brains. For the present purpose, though, it seems sufficient to study the process of socioeconomic change at the level of individuals who interact with other individuals. Secondly, the members of any population for any given point in time can be sub-divided into disjoint groups (states) according to further measurable individual characteristics in addition to age and sex. As age changes in tandem with chronological time, it presents a special characteristic for forecasting. Over time, people stay in their state and simply become one year older every calendar year, unless they decease or transition to another state. Therefore, possible applications of the theory of demographic metabolism are designed to split up the entire population by the particular characteristics of interest and subsequently to sub-divide all members of this category by age and sex. Thirdly, at any point in time, members of a sub-population (state) defined by certain characteristics can move to another state (associated with

different characteristics), and these individual transitions can be mathematically described by a set of age- and sex-specific transition rates. Whether a transition to another state occurs inside the system (e.g. national population), as well as to an absorbing state (e.g. death), or to a state outside the system (e.g. out-migration) does not affect the applicability of the method. New individuals arriving (through birth or in-migration) will be immediately allocated to one of the states within the respective system. However, not all transitions among a given set of states have to be possible. Sometimes, transitions may be only possible in one direction, such as from lower to higher educational categories or from the single to the married state, from which people may move to the divorced or widowed state. Finally, the fourth proposition states that if any given population consists of sub-groups that are significantly different from each other with respect to relevant characteristics, then a change over time in the relative size of these sub-groups will result in a change in the overall distribution of these characteristics in the population and hence in socioeconomic change.

The choice of a characteristic that is worth studying with respect to its changing distribution within a society is context-specific and hence the definition of the relevant sub-groups dependent on the research questions asked. In this paper, we will discuss and present three such characteristics: Highest level of educational attainment, the degree to which a person says to have a European identity in addition to a national one, and the degree to which a person

expresses tolerance towards homosexuality. We chose these three different applications of the predictive power of the theory of demographic metabolism not only to cover a broad range of topics, but also because of characteristics that have different numbers of disjoint categories: for education we will look at four categories ranging from never been to school to post-secondary education, for European identity we look at a dichotomized variable, and with respect to tolerance to homosexuality we study a range of 10 categories that can be regrouped in different ways.

## The Multi-dimensional Cohort-component Model

Many demographic methods are based on the concept of the life table and deal with the transitions of people from one state to another over a certain time interval. In its most fundamental form, a life table distinguishes only between two states, being alive and being dead (single decrement life table), and is constructed on the basis of age-specific mortality rates which are used to derive probabilities of surviving to certain ages, as well as expected remaining years of life at any given age. Since age-specific mortality rates differ substantially by sex, there is a long tradition to calculate life tables separately for men and women.

Aside from this standard differentiation by age and sex, however, conventional demography still considers populations as largely homogeneous —for example, it is typically assumed that for all men aged 50–54 the risk of death is equal, despite large differentials related to clearly identifiable risk factors, such as smoking, obesity, or level of educational attainment (Ref.). In the multi-state case, this restriction is relaxed and mortality rates can be different for sub-groups depending on further distinguishing characteristics. The multi-state model is based

on the generalization of the simple life table to multiple-decrement and increment-decrement life tables (Rogers 1975; Schoen and Nelson 1974; Keyfitz 1985). In essence, such tables describe movements of people that can go back and forth between more than two states and where transition rates differ depending on the current state. These advances in methodology, were made in the 1970s mostly by scholars affiliated with the International Institute for Applied Systems Analysis (IIASA). Beyond the analytical model it also led to the development of the multi-state population projection model that can simultaneously project the populations of different categories (states, regions) with different fertility, mortality, and migration patterns, as well as movements among the categories.

Initially focused on regionally defined states, applications were expanded further to analyze marital status transitions (Schoen and Nelson 1974), labor force participation and working life tables (Willekens 1978), health and morbidity status (Manton 1988), and cross-classifying marital status and number of children (Lutz 1989). To our knowledge, the application of the multi-state projection model to education was first used in a study of population–development–environment interactions on the island of Mauritius (Lutz 1994).

## The Demography of Human Capital Formation

The multi-state model described above is most powerful for projecting the future distributions of characteristics that are sticky, i.e. rather enduring over the individual life cycle beyond young age. One such characteristic, which is normally acquired at younger ages and then maintained throughout life, is the highest level of educational attainment, where by definition people cannot move back to lower levels, even if their cognitive abilities should

decline with age. While primary and secondary education are typically completed by the early 20-ies, the completion of higher education can also take place at later stages of the life cycle, particularly in developing countries. But the multi-state model can also accommodate for different schedules of age-specific transitions to higher levels of education.

When we look at the distribution of educational attainment by age in countries where education has increased rapidly in the past, this stickiness of educational attainment over the life cycle becomes particularly noticeable. Figure 1 shows the education and age pyramids for Singapore as reconstructed and projected applying the model of multi-dimensional cohort-component model (Lutz and KC 2011, Lutz et al. 2007). In this figure, four educational categories are superimposed on the conventional age pyramid through color shading: red corresponds to "never been to school", yellow "some primary education", green "completed junior secondary education", and blue "completed first level post-secondary or higher". The phenomenal expansion in educational attainment of the Singaporean population over the past 60 years are clearly visible in comparing the graphs for 1960, 1990 and 2020. This may well reflect (together with South Korea) the fastest and most remarkable expansion in formal education in human history. While in 1960 the majority of the female population above age 20 had never attended school, 30 years on the population below age 40 already approached universal secondary education, although the cohorts above age 50 persisted to be very poorly educated. A visitor to Singapore around 1990 found there a deeply divided society: The shiny streets and shopping malls where populated by well-educated, young people dressed in Western clothes who spoke perfect English and embraced the latest technology far more than Europeans at the time. But once you went around the corner to the backside of the building, you found yourself

in a poor developing country with elderly people, speaking only Chinese, living in a parallel world. It was a society divided into two classes. But unlike the self-reproducing classes, more common in sociology, these were classes defined by age-cohort membership: The older ones, who were of school age when Singapore was still a very poor country without much of a school system, and the younger ones, who already could benefit from the very rapid expansion of the school system since the late 1950s. And unlike the class structure of a society, these cohort-based classes were scheduled to disappear with the passage of time, as the less educated cohorts continue to move up the age pyramid until they pass away: demographic metabolism at work.

Figure 1: Age and education pyramids in Singapore 1960-2020 with colors indicating different educational attainment categories

As the third pyramid in Figure 1 shows, by 2020 most of the uneducated older cohorts in Singapore will have disappeared, whereas the young population, especially women, will be among the most educated in the world with around 80 percent of them having post-secondary education. Hence, through this process of demographic metabolism, Singapore in 2020 will be a different society and a difference economy in almost every possible aspect than it was in 1960.

The data plotted in Figure 1 for Singapore is derived from a systematic reconstruction and projection of educational attainment distributions by age and sex for more than 170 countries in the world (Lutz et al. 2007, KC et al 2010, Lutz and KC 2011, Lutz, Butz and KC 2014). The reconstruction is based on the past age and sex distributions as given by the UN

Population Division and for that reason only needed to account for differential mortality (and where possible migration) by level of education. This resulted in a unique new data set which is more comprehensive and detailed than other existing data sets of the past education distributions (e.g. Barro and Lee 201X). Also, it is the first data set of its sort to explicitly take differential mortality by level of education into account.

These new systematic data on past global educational attainment distributions by age and sex were already reassessed in relation to several important aggregate level returns to education ranging from economic growth to health, quality of institutions, and resilience to natural disasters (Lutz Phil Trans – sola schola). Economic theory had long predicted that education has an important positive influence on aggregate-level economic growth, but the results from growth regressions had been inconclusive up till recently (Becker 1993, Barro and Sala-i-Martin 2003, Benhabib and Spiegel 1994, Pritchett 2001). Most of these studies used as education indicator the mean years of schooling of the entire adult population above age 25. But as Figure 1 clearly shows, e.g. in 1990 in Singapore, this crude indicator evens out differences in the human capital of the elderly uneducated cohorts and that of the highly educated young ones. As a result, the change over time of this crude indicator contains little statistical signal and does not show a strong correlation with the increase in economic growth which started in Singapore when the better educated cohorts entered the young adult ages. A more recent study that estimates economic growth regressions using the new age-specific human capital indicators described above showed consistently positive and significant effects of educational attainment on economic growth (Lutz et al. 2008). By including the full educational attainment distributions (and not just mean years of schooling), this study also showed that for the poorest countries it is essential to complement primary education with broad based secondary education

in order to achieve economic growth. It also showed that focusing on universal secondary education has a stronger effect on poverty eradication than prioritizing tertiary education in an otherwise largely uneducated population. Following this rationale, the recently adopted United Nations SDGs (Sustainable Development Goals) added universal secondary education to the Millennium Development Goal (MDG) of universal primary education.

Besides economic growth, this cohort-specific human capital data was also used to reevaluate at the aggregate level returns to education. For instance, it could be shown that the time when large cohorts of better educated men and women enter the young adult ages is of crucial importance for transformation of societies to modern democracies, as assessed through an analysis of global time series data (Lutz et al, Democracy, PDR 2010). Also, several studies have illustrated that female education plays a key role in reducing fertility in countries with very high rates of population growth, as more educated women generally have lower desired family sizes, are more empowered to pursue their own wishes against that of other family members, find better access to contraception and hence consistently have fewer children (Lutz and KC 2011 – Science). Moreover, throughout the world more educated women have lower infant mortality and live longer themselves. (Lutz, Butz and KC 2014). Finally, recent analyses of the role of education in reducing vulnerability to natural disasters around the world indicated that level of education is a more important factor in reducing vulnerability than income and, hence, is crucial for enhancing societies' adaptive capacities to global climate change (Lutz et al. 2014 – Science). All of these studies on the beneficial consequences of educational expansion utilized education distributions by age and sex that were reconstructed using the concept of demographic metabolism.

But the demographic metabolism does not only help decomposing and analyzing past changes. It is a particularly powerful and operational concept for forecasting future changes of the population composition along cohort lines. If we know, for instance, how many 25-year old women have completed secondary education today, this is a very good basis for projecting how many 65-year old women with at least secondary education there will be alive 40 years into the future. One only has to adjust for the possibilities of education-specific mortality risks and migration. The predictive power of this model thus derives directly from the fact that human lives today tend to last more than 70 years and hence the future composition of the population is partly predetermined for decades into the future by the current composition. The uncertainty that remains nevertheless is a consequence of different possible future fertility, mortality and migration rates which can be portrayed quantitatively in the form of alternative scenarios of fully probabilistic population projections (Lutz and Goldstein, Lutz et al 2x Nature, UN Science). In the case of multi-dimensional projections by level of education, it has to be assumed that a person's highest educational attainment remains invariant after a certain age. Alternatively, one can also assume certain rates of transitions to higher levels at later ages. This has been the basis for the projected education pyramid in the lower panel of Figure 1 for Singapore in 2020. The further one goes out into the future the lower is the proportion that is already predetermined by the current age and education distribution and the broader the range of uncertainty. In the context of producing a new set of scenarios for the international climate change modelling community – the so-called SSPs (Shared Socioeconomic Pathways) – a major recent effort involving more than 550 international population experts has produced the "human core" of these SSPs in the form of alternative scenarios by age, sex and six levels of

educational attainment for all countries in the world (Ref OUP book, O'Neill et al SSP concept).

While multi-dimensional population projections based on the demographic metabolism have become state of the art in demographic forecasting (mostly without explicitly referring to this notion as coined by Ryder), it is also applicable to many other fields where we experience social change. The remaining part of the paper will deal with such applications outside the more narrowly defined realm of demography.

**The Demographic Metabolism of European Identity**

Highest level of educational attainment is usually considered to be a "hard" variable such as age that can even be validated through official certificates. But there are other human characteristics that are "soft" in the sense that they can only be assessed through the expressed personal opinion of people in a survey and that can easily change over time. In this section we will show that the model of demographic metabolism can also be applied to such softer subjective and possibly more volatile characteristics. We will focus on the changing pattern of European identity as opposed to strictly national identities as it has been assessed by the Eurobarometer surveys over many years.

Some political commentators and observers of the recent economic crisis and its associated effects on the Euro, as well as the future of the European Union more generally speak of an apparent revival of nationalism in many EU member countries and the distinct possibility of dissolution of the EU as a result. The widely used argument is that besides existing economic interdependencies (especially in the banking sector), there isn't much that is

holding the EU together and that under financial stress as well as under the stress of the current refugee inflows, these interdependencies may actually turn into centrifugal forces. But these commentators focus too narrowly on the institutions and day to day politics and tend to overlook the inertia of opinions and more deeply rooted identities of the citizens that Europe is comprised of.

The European Commission routinely gathers information of these questions in its Eurobarometer surveys. The relevant question on European identity asks: "In the near future, do you see yourself as [Nationality] only, as [Nationality] and European, as European and [Nationality] or European only?" Since 1996, this question has been asked with unchanged wording more than a dozen times in the EU-15 (members of the EU as of 1995) with national samples of around 1,000 in each round. In 2004, 42 percent of the adult population of the EU-15 above age 18 identified themselves as solely nationals of their own country, whereas 58 percent gave an answer that reflected multiple identities including a European identity. Figure 2 shows a clear decline in association with multiple identity with age. Put differently, the older the respondent, the greater the chance that he or she will perceive only a national identity. While for younger age groups, those with only national identities are a minority, for the population above age 60 they constitute a majority.

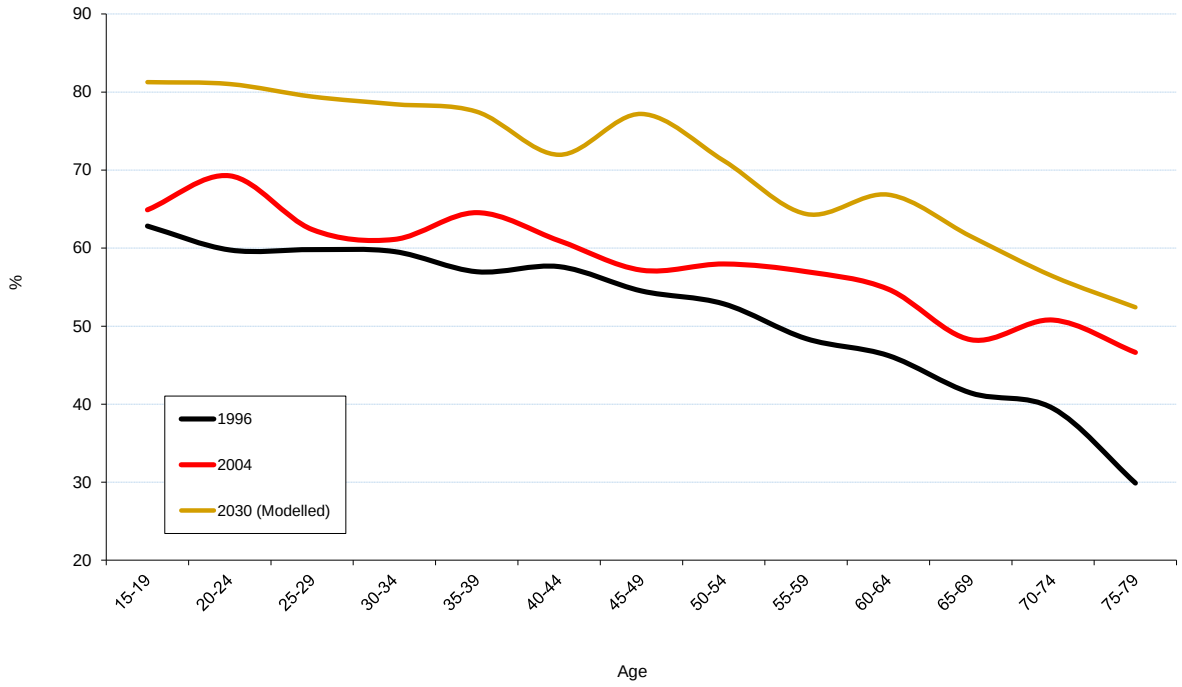


Figure 2: Proportions with multiple identities by age as derived from the Eurobarometer Surveys in 1996 and 2004 and projected to 2030 (Source: Lutz et. al 2006)

Does this obvious age pattern allow for the conclusion that as people get older, they tend to develop a stronger national identity and abandon multiply identities they might have had earlier? If this dominance of the age effect were to be true, the massive population aging that will occur over the coming decades simply as a consequence of the current age-structure would suggest a decline in the proportion of citizens with multiple identities. On the other hand, the same pattern could also be interpreted in terms of a cohort effect: young cohorts are being socialized in a way that produces a higher prevalence of multiple identities than found among the older cohorts which they then maintain throughout their lives. As a result, we should observe significant increases in future European identity through demographic metabolism,

with the younger, more European-minded cohorts replacing the previous, more nationalistic ones.

Both of these contrasting interpretations are plausible. However, their validity cannot be assessed empirically based on one cross-sectional survey alone. Only panel data that provides age profiles at different points in time allow us to distinguish between age and cohort effects. Using data from 1996 and 2004, Lutz, Kritzinger, and Skirbekk (2006) find evidence of a highly significant, positive cohort effect which is indicative of a trend toward greater prevalence of multiple identities in the European Union along cohort lines. In other words, cohorts born more recently are socialized in a way that decreases their association with solely national identities and increases the association with multiple identities. These identities are then assumed to be maintained throughout their lives, while for the subsequent younger cohorts, for which no empirical data is available, the authors assume the continuation of the time trend of past inter-cohort increases. Based on this model of demographic metabolism, they predicted that by 2030 the proportions with European identity would come to lie over 70 percent for the younger people and over 50 percent even for the older ones. In terms of absolute numbers, the results predict that only 104 million adult European Union citizens (EU-15) will have strictly national identities in 2030, while 226 million will have multiple identities.

Since the publication of this paper in 2006, the European Union has gone through turbulent times. As stated above, many commentators in the media think that as a consequence the pattern has fundamentally changed and people now identify less with Europe than before. These views are typically only based on conjectures rather than solid empirical information, when in fact in 2013 the exactly same question was asked to Europeans in the course of another Eurobarometer survey. Thus, whether the projections published in 2006 were far off the mark –

as most would expect – or had indeed captured a still ongoing secular trend, can be assessed empirically.

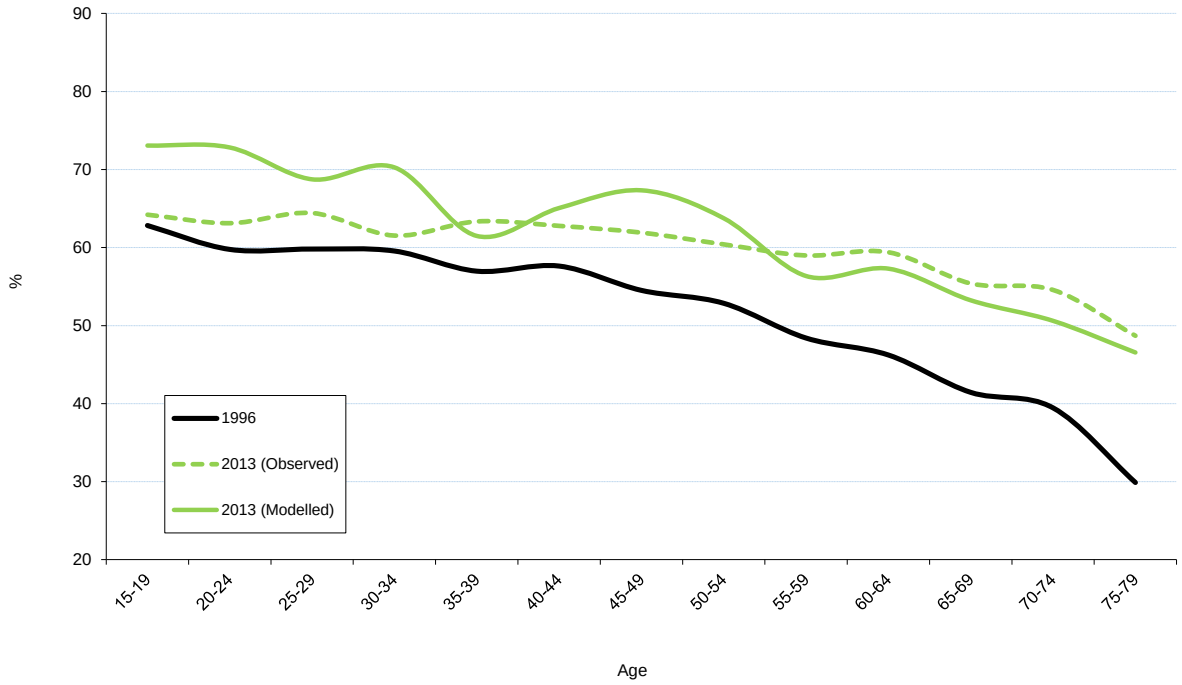


Figure 3: Proportions with multiple identities by age as derived from the Eurobarometer Surveys in 1996, projected to 2013 (based on the Lutz et al model) and actually observed in 2013.

The two green lines in Figure 3 show the age pattern of European identity as projected in the 2006 paper for 2013 (solid) and the actual pattern observed in the 2013 survey (dashed). Considering broad age groups, this empirical test of the past predictions shows that for cohorts that are above age 35 in 2013 the forecast was pretty accurate, while for the younger age-groups

the forecast was too high. In fact, for the age groups 15-24 the actual proportions with multiple identities were 8-9 percentage points lower than the forecast ones. This clearly shows that the above-stated assumption of continuation in the trend of inter-cohort increases as observed for the 1994-2004 period to 2013 did not hold. For the new cohorts that had entered adult age during the projection period, clearly the increasing trend had stalled over the last decade. However, for adults of higher ages the assumption of stability of identifies along cohorts lines essentially held. There is some noise around the specific smaller age groups, but taken together the European adult population above age 35 in 2013 shows almost exactly the proportion with European identity (57.9 percent) as was projected based on 1996-2004 data for the year 2013 based on the model of demographic metabolism (58.6 percent). This is indeed a strong confirmation of the predictive power of the model even during turbulent times when most observers would have expected the opposite.

These findings suggest that the relentless forces of cohort replacement, through which younger and (up to the most recent cohorts) more European-minded cohorts gradually take the place of the older, more nationally oriented cohorts, produce significant and predictable changes in the pattern of European identity. Since the population aged above 35 constitutes a vast majority of the total European electorate (as well as of decision makers and politicians), these predictable changes in the composition of the adult population will presumably important long-term implications for fundamental political and economic developments in Europe, even though short-term politics and market reactions are likely to remain volatile.

Another important finding from this empirical assessment of the predictive power of the model of demographic metabolism for a soft, subjective and potentially changeable characteristic such as expressed identity is that in contrast to stable cohort patterns, the period

changes determining the formation of the identities of the younger generations are indeed reversible and there is no guarantee for a continuation of observed period trends. In other words, while the firmly established identities of many adults do not seem to have changed very much in response to the widely publicized and discussed crises of European institutions, these discussions have interrupted the trends with respect to the formation of such identities among the younger cohorts. This leaves us with an important message for forecasting social trends in general: Trend extrapolation is a much less reliable approach to anticipating future developments than decomposing the population into cohorts, assessing the stability of patterns along cohort lines, and then modelling the changing composition of the population through the demographic metabolism.

## The changing pattern of tolerance toward homosexuality

The above-described example of identity is rather specific to the European context, although the more general concept of multiple (not only national) identities and their stability and change over time is also relevant for other countries (see also Josselson and Harway 2012; Kivisto 2015). Another very significant value change that has been observed in virtually all industrialized countries in recent decades is the attitude and tolerance toward homosexuality. This topic will be chosen in the following for another, entirely new application of the demographic metabolism. Using data from the European and World Values Survey (hereafter EWVS), we will assess the empirical patterns in selected countries since the 1980s and derive projections of the future prevalence of tolerance toward homosexuality in those countries until 2040.

The EWVS represents the largest collection of data on attitudes and values to date with a total of roughly 500,000 not repeated individual observations. The EWVS has been carried out in six waves since 1981 – the latest of which (2010-2014) has only recently been released and so far not been used for statistical research very widely. Starting out with a heavier focus on European countries, over the years the EWVS has become ever more global in scope. In total, representative national surveys with between 1,000 and 3,000 individuals from the entire resident population above the age of 18 have been conducted in almost 100 countries, accounting for close to 90 per cent of the world population. Country-level weights are provided reducing sampling bias and ensuring that the data for each country-wave combination are representative. Detailed information on the sampling strategy, questionnaire wording, as well as data access and publications making use of this data can be obtained at www.worldvaluessurvey.org.

Respondents in all survey waves of the EWVS so far were asked with the precisely same wording to give an assessment of their "Tolerance for homosexuality" on a 10-level scale: "Please tell me whether you think it can always be justified (10), never be justified (1), or something in between." Due to the risk of differential item functioning, i.e. subjective assessments regarding one's level of tolerance might not be comparable across different national and cultural contexts, we study only individual countries, rather than pooling the data across all countries available. From the many countries that are included in the EWVS, we select three for which long series of data exist, which show distinctly different patterns and also have very different cultural and religious backgrounds, namely Japan, Spain and the United States of America.

Before going into the statistical analysis, we first visually inspect the trends and patterns in these countries in a form that already decomposes the pattern into different birth cohorts. The following Figures 4-6 show the time trends in the proportions of respondents stating that homosexuality can be justified for different birth cohorts in the years in which the surveys were taken. This allows us to visually distinguish the change that is due to changing attitudes within birth cohorts over time (shown by the slope of the lines) and that resulting from younger cohorts being on average more tolerant (vertical difference between the lines). When dichotomizing the data for easier presentability, we chose values of 6 or higher to correspond to tolerance, but note that the shape of the curves or their relative position only changes marginally when shifting the "neutral" middle category to the tolerant side. The size of the circles around each data point corresponds to the number of observations. Note that both for the oldest cohorts in the most recent waves, as well as for the youngest cohorts in the earliest waves, the number of observations was sometimes either no longer, or not yet high enough.

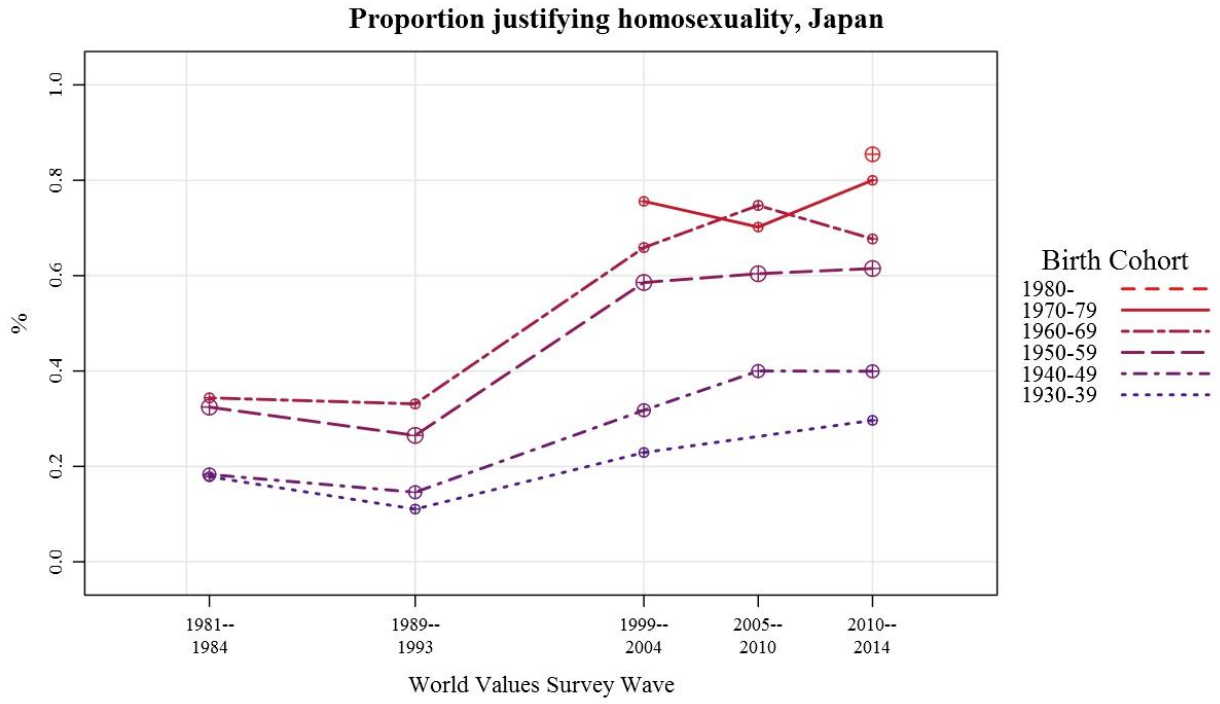


Figure 4

Figure 4 shows the empirical pattern for Japan. It indicates that in the early 1980s, among the cohorts born before 1950 less than 40 percent expressed tolerance toward homosexuality, while for the cohorts born 1950-1969 more than 60 percent expressed tolerance. In the most recent round of surveys taken after 2010, all cohorts show a somewhat higher proportion tolerant than 20 years before, i.e. they somewhat changed their views over time into the direction of more tolerance with most of the change happening during the 1990ies. But the inter-cohort difference dominates the picture. The proportions range from 50 percent for those born 1930-39 to over 90 percent for cohorts born after 1970. The ranking of the cohorts with respect to tolerance follows exactly their age where the difference between those born in the 1940s and in the 1950s seems to be particularly large, i.e. almost 20 percentage points.

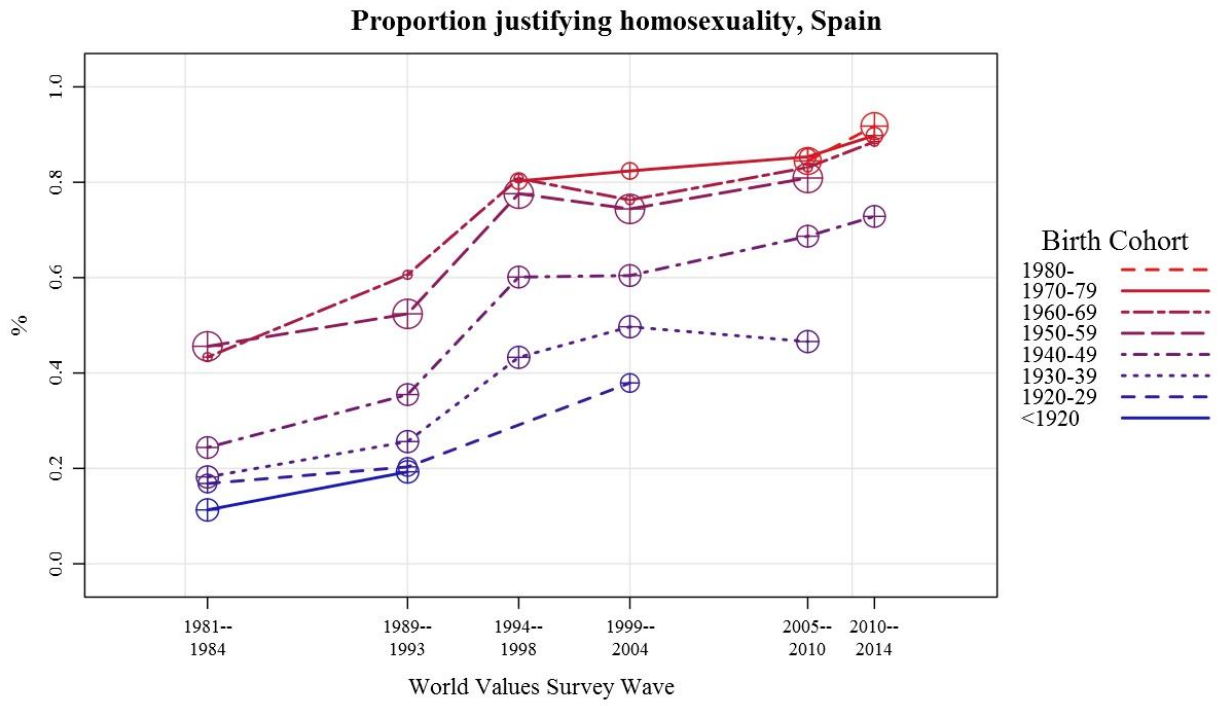


Figure 5

For Spain (see Figure 5) the pattern of change looks somewhat different. Over the 1980s the inter-cohort difference is bigger than in Japan, even when considering that here we also have a high enough number of observations from cohorts born before 1930. There are very little intra-cohort changes visible during the 1980s and since 2000 but a massive shift during the 1990s for all cohorts. This is the time when the Spanish society went through massive modernization and a stronger interaction with Western Europe. Since 2000 virtually all of the change has been through cohort replacement with the cohort lines being essentially flat. It is also worth noting that for the younger cohorts the values are already so close to 100 percent that not much further increase has been possible.

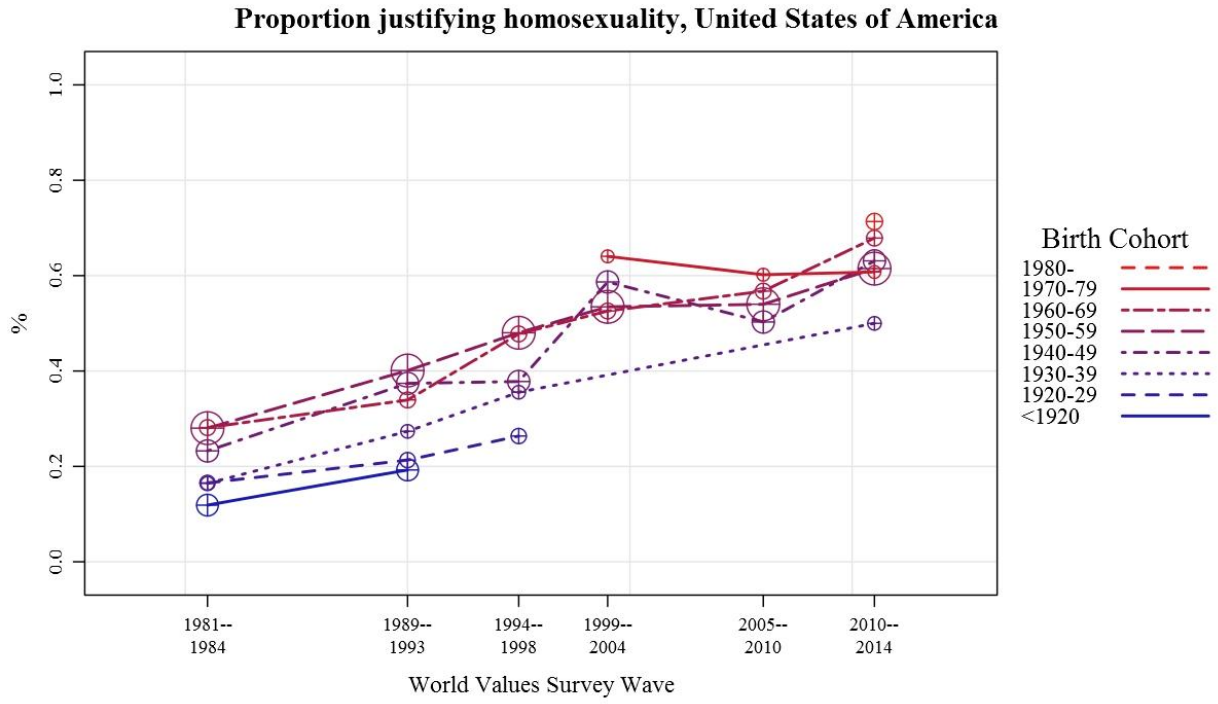


Figure 6

The picture for the USA (Figure 6) is very different from Japan and Spain. There is less inter-cohort change and within cohorts moderate almost linear increases are shown up to 2000. It is also remarkable that, unlike in Japan and Spain, the proportion does not increase beyond 80 percent being tolerant. Except for the oldest cohort, born before 1940, the average level of tolerance has been stagnant since 2000. This pattern, and in particular the levelling off well below 100 percent, may be a consequence of strong heterogeneity in the population with sizable sub-population that do not follow the secular as well as the inter-cohort trend towards more tolerance.

| | Japan | Spain | USA |
|---|---|---|---|
| survey year | 0.019*** | 0.011*** | 0.035*** |

| | | | |
|---|---|---|---|
| | (0.003) | (0.002) | (0.002) |
| birth cohort | 0.055*** | 0.028*** | 0.005** |
| | (0.003) | (0.002) | (0.002) |
| educ: med/low | 0.169*** | 0.409*** | 0.046* |
| | (0.040) | (0.042) | (0.027) |
| educ: high/low | 0.603*** | 0.655*** | 0.759*** |
| | (0.033) | (0.033) | (0.029) |
| sex: male/female | -0.584*** | -0.423*** | -0.485*** |
| | (0.064) | (0.046) | (0.049) |
| religion: religious/not religious | -0.179** | -0.754*** | -1.078*** |
| | (0.072) | (0.050) | (0.059) |
| married: cohabiting | 0.051*** | 0.257*** | 0.541*** |
| | (0.000) | (0.011) | (0.015) |
| married: divorced | 0.250*** | 0.321*** | 0.217*** |
| | (0.003) | (0.003) | (0.019) |
| married: separated | 0.105*** | 0.278*** | -0.052*** |
| | (0.000) | (0.003) | (0.002) |
| married: single or never married | -0.010 | 0.012 | 0.328*** |
| | (0.012) | (0.057) | (0.061) |
| married: widowed | -0.049*** | -0.247*** | -0.167*** |
| | (0.004) | (0.011) | (0.011) |
| Log-likelihood | -6842.920 | -12652.227 | -10459.111 |
| Deviance | 13685.839 | 25304.453 | 20918.221 |
| AIC | 13725.839 | 25344.453 | 20958.221 |
| BIC | 13848.710 | 25479.679 | 21090.998 |
| N | 3441 | 6382 | 5646 |

Table 1. Do you justify homosexuality? Weighted ordered logistic regression results for Japan, Spain, and USA. *** p<0.001, ** p<0.01, * p<0.05, standard errors in parenthesis.

Table 1 gives the results for the three countries of full models with many of the usual controls and determinates of tolerance toward homosexuality as mentioned in the literature (Refs)

While such a model is useful for studying the various drivers of change (discuss education effect as being partly covered by cohort effect) it is inappropriate for forecasting because we do not know the future trends of the independent variables.

Following the concept of demographic metabolism we based projections only on the mechanism of cohort replacement with the assumption of some stability of the attitudes within cohorts. To be more precise, we do as a minimum assume that tolerance within cohorts does not decline over time. This seems to be a rather uncontroversial assumption because in none of the cohorts studied in any of the countries there was a lasting decline observed (aside from temporary dips that may also be due to small numbers of cases). On the other hand, as we have seen in the analysis above there has been in most countries some intra-cohort increase in the proportion expressing tolerance over time. But it is not clear whether this trend will continue in

the future. For this reason we specify two scenarios in our forecasts, one in which proportions tolerant will be constant within cohorts over time and another one where an extrapolation of the observed trend – in the form of the estimated period effect – will be superimposed to the increase that results purely from cohort replacement.

| | Japan | | | Spain | | | USA | | |
|---|---|---|---|---|---|---|---|---|---|
| | m1 | m2 | m3 | m1 | m2 | m3 | m1 | m2 | m3 |
| birth cohort | 0.06*** | 0.06*** | | 0.04*** | 0.04*** | | 0.02*** | 0.01*** | |
| | (0.00) | (0.00) | | (0.00) | (0.00) | | (0.00) | (0.00) | |
| survey year | | 0.02*** | 0.05*** | | 0.02*** | 0.05*** | | 0.04*** | 0.05*** |
| | | (0.00) | (0.00) | | (0.00) | (0.00) | | (0.00) | (0.00) |
| sex: male/female | -0.45*** | -0.46*** | -0.45*** | -0.23*** | -0.22*** | -0.13*** | -0.32*** | -0.33*** | -0.31*** |
| | (0.06) | (0.06) | (0.06) | (0.04) | (0.04) | (0.04) | (0.05) | (0.05) | (0.05) |
| Log-likelihood | -6942.38 | -6940.06 | -7355.33 | -12888.97 | -12880.63 | -13496.49 | -10844.65 | -10791.73 | -10839.72 |
| Deviance | 13884.75 | 13880.12 | 14710.65 | 25777.93 | 25761.27 | 26992.98 | 21689.29 | 21583.46 | 21679.43 |
| AIC | 13906.75 | 13904.12 | 14732.65 | 25799.93 | 25785.27 | 27014.98 | 21711.29 | 21607.46 | 21701.43 |
| BIC | 13974.44 | 13977.96 | 14800.33 | 25874.32 | 25866.42 | 27089.51 | 21784.33 | 21687.14 | 21774.47 |
| N | 3474 | 3474 | 3474 | 6393 | 6393 | 6473 | 5651 | 5651 | 5651 |

Table 2. Do you justify homosexuality? Weighted ordered logistic regression results for Japan, Spain, and USA. *** p<0.001, ** p<0.01, * p<0.05, standard errors in parenthesis.

Table 2: Models with only cohort and time as independent variables, three countries (m1=only cohort, m2=cohort and year, m3= only year)

The results of these two different scenarios to 2040 are given in Table 3 for the three countries that are studied here. Under the scenario that assumes constant proportions tolerant for individual cohorts the model shows for Japan an increase from currently 46 percent tolerant to 72 percent in 2040. If the time trend is added then the proportion would increase to 80 percent in 2040. This same proportion of 80 percent would be reached in Spain even without adding a time trend because there the overall proportion is already much higher than in Japan. The resulting age pyramids for Japan and Spain are given in Figure 7 for the scenario without time trend.

The USA is a quite different case because the above described analysis already revealed that there the time trend is more important than the inter-cohort cohort changes. Consequently, under the scenario assuming constant proportions for cohorts the proportion tolerant would only increase from the current 41 percent to 57 percent in 2040. Adding the time trend to the projection would result in 75 percent by 2040. The corresponding evolutions of the age pyramids for the two scenarios for the US are given in Figure 8.

| | | Entire Population | | | Population above age 40 | | |
|---|---|---|---|---|---|---|---|
| Attitudes | Year | Japan | Spain | USA | Japan | Spain | USA |
| Constant | 2010 | 0.62 | 0.78 | 0.62 | 0.52 | 0.72 | 0.59 |
| Constant | 2015 | 0.66 | 0.81 | 0.64 | 0.57 | 0.75 | 0.60 |
| Constant | 2020 | 0.70 | 0.83 | 0.66 | 0.62 | 0.78 | 0.62 |
| Constant | 2025 | 0.74 | 0.85 | 0.68 | 0.67 | 0.81 | 0.63 |
| Constant | 2030 | 0.77 | 0.87 | 0.71 | 0.72 | 0.83 | 0.65 |
| Constant | 2035 | 0.81 | 0.88 | 0.73 | 0.76 | 0.85 | 0.67 |
| Constant | 2040 | 0.84 | 0.90 | 0.75 | 0.80 | 0.87 | 0.69 |
| Time Trend | 2010 | 0.62 | 0.78 | 0.62 | 0.52 | 0.72 | 0.59 |
| Time Trend | 2015 | 0.68 | 0.82 | 0.68 | 0.59 | 0.77 | 0.65 |
| Time Trend | 2020 | 0.73 | 0.85 | 0.73 | 0.66 | 0.81 | 0.70 |
| Time Trend | 2025 | 0.78 | 0.88 | 0.77 | 0.72 | 0.85 | 0.75 |
| Time Trend | 2030 | 0.82 | 0.90 | 0.82 | 0.78 | 0.87 | 0.80 |
| Time Trend | 2035 | 0.86 | 0.92 | 0.85 | 0.82 | 0.90 | 0.83 |
| Time Trend | 2040 | 0.89 | 0.93 | 0.88 | 0.87 | 0.92 | 0.87 |

**Table 3. Proportion justifying homosexuality among the entire population and among the population above the age of 40 in two scenarios: Constant (attitudes frozen at cohort-specific levels) and Time Trend (attitudes becoming increasingly more tolerant following the time trend), Japan, Spain, and United States of America, 2010 - 2040.**

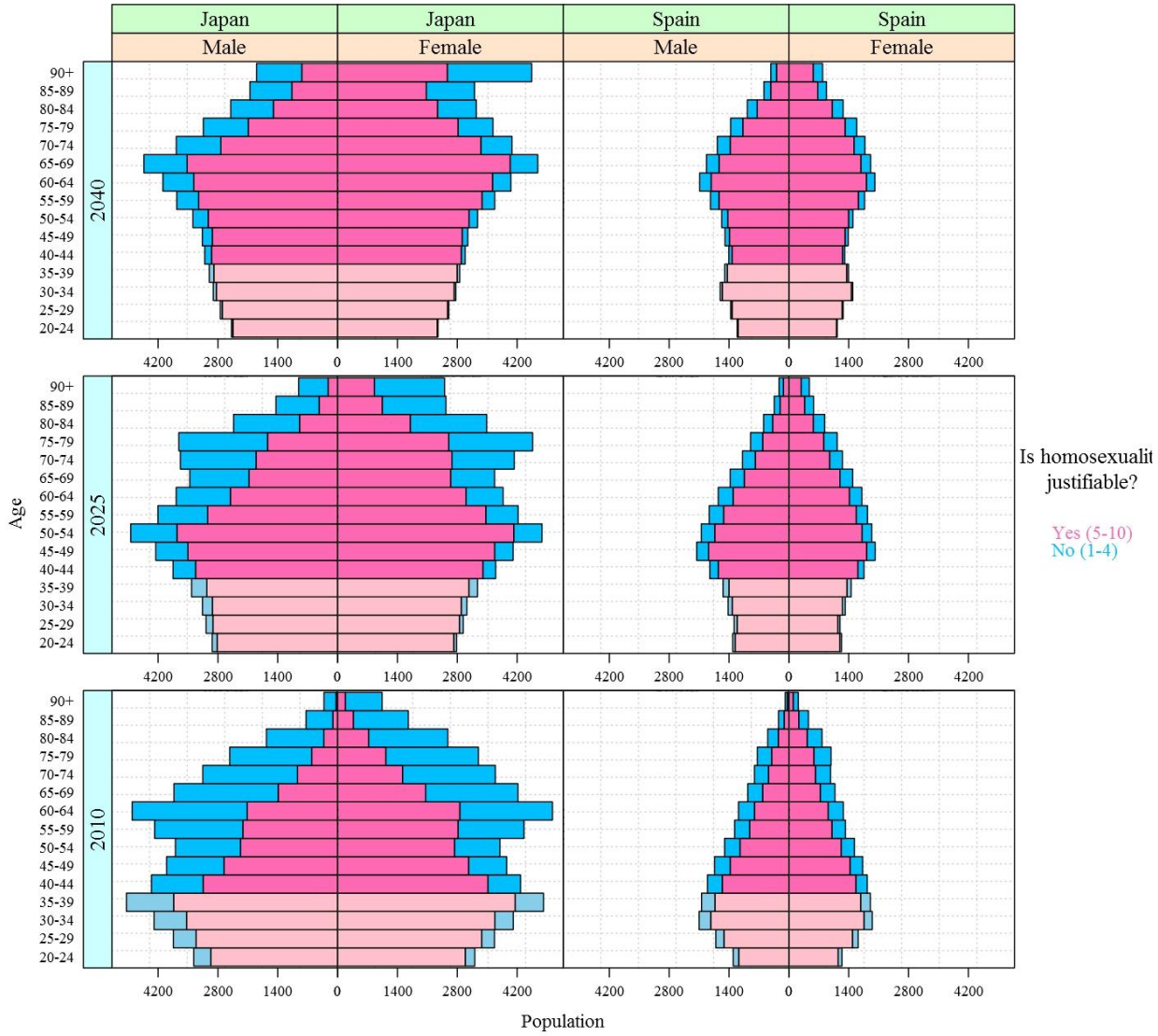


Figure 7: Pyramids for Spain and Japan (old left sides without time trend)

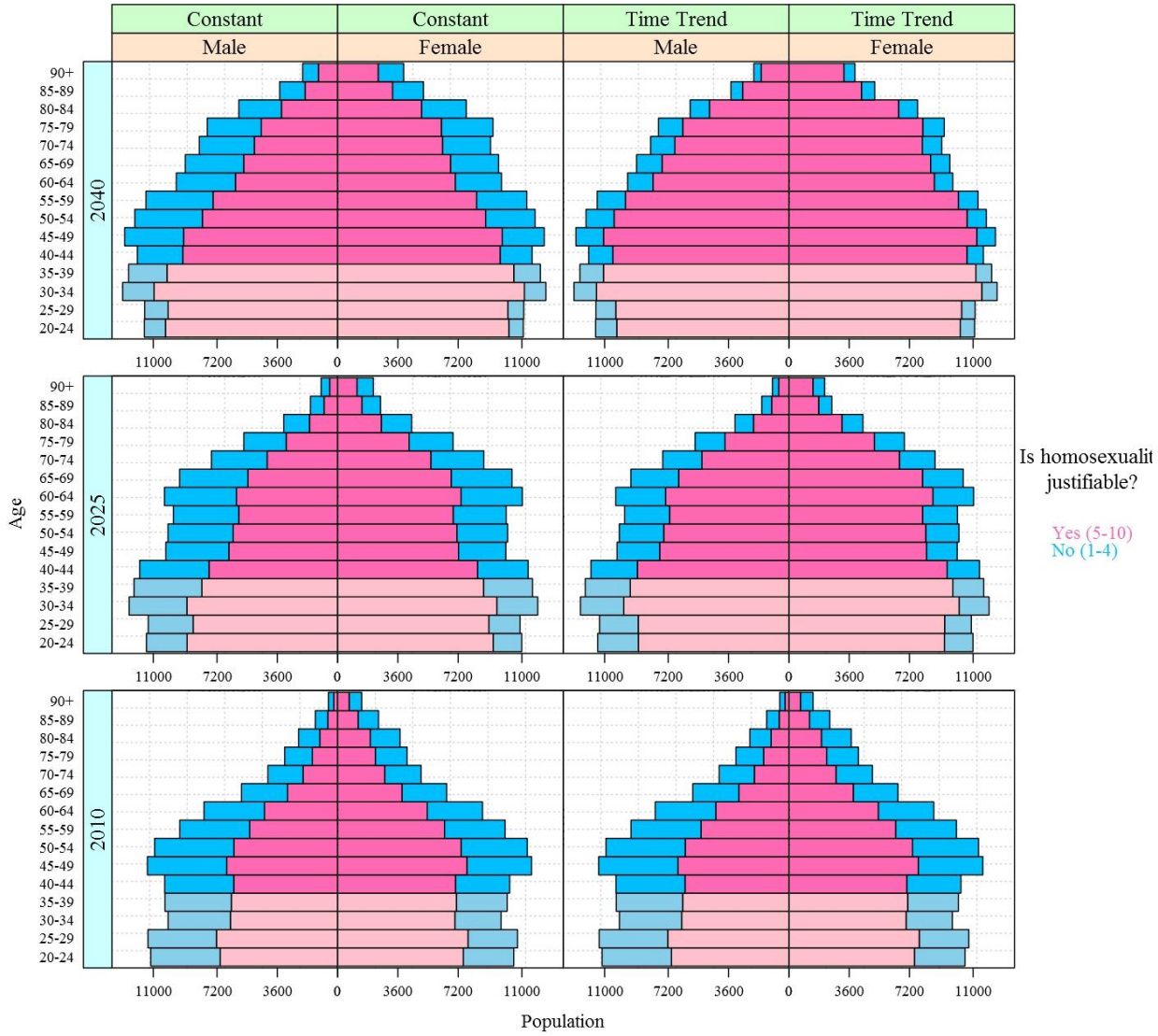


Figure 8: Pyramids for US with and without trend

Summary of Tolerance section

## Discussions and outlook (still to be redone)

## Talk about limitations and potentials

This refers primarily to the above described fact that improvements in educational attainment of the adult population and the associated empowerment of the citizens must take account of the fact that education mostly happens at young age and therefore investments today and in the near future will take decades to translate into a significant improvement of the average educational attainment of the adult population. From this fact two important policy messages can be derived: First, one has to be patient in expecting the benefits of current investments in education; and secondly that the benefits associated with better education will come surely and in a predictable way in the longer run.

The process of demographic metabolism itself is neutral and only describes the process of change without saying whether the change is to the better or worse. But the theory of demographic metabolism tells us that any sustainable betterment of society needs to work – at least in part – through the process of generational replacement. There is a limit to the degree to which people can change at a higher age when it comes to fundamental skills or attitudes or simply important experiences made during earlier parts of one's life. A recent example for this is the discussion in Germany and Austria of the crimes committed by the "Wehrmacht" during World War II. Despite all efforts for an open and objective discussion of the historical facts, the topic turned out to be too difficult for many members of the generation that still actively participated in the war. It had to wait until a new generation, socialized after the war, could address the issue more objectively. Another example is the fall of the iron curtain in Europe where many political commentators expected that the differences between East and West would quickly disappear. But the change in political institutions is only one aspect that can happen rather quickly. The people are still the same as they were before the fall of the iron curtain and

again in many aspects it requires a generational change for mentalities based on different socialization and experiences of the East and the West to grow together.