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Interim Report IR-12-009

Demographic Metabolism: A Theory of Socioeconomic Change with Predictive Power

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June 25, 2012

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Abstract

Inspired by the work on social change through generational/cohort replacement of Karl Mannheim and Norman Ryder—who coined the notion of Demographic Metabolism—this paper suggests the application of the methods of multi-dimensional mathematical demography to forecast the changing composition of the population by relevant individual characteristics that go far beyond the traditional age, sex and place of residence. It is claimed that unlike many so-called theories in the social sciences—which mostly are just classification schemes—this model actually meets the falsifiability criteria of Popper and Lakatos that for the latter distinguishes a theory from "pseudoscience". As presented here, this theory can make quantitative predictions of socioeconomic change with only a narrow margin of uncertainty for decades into the future. The paper gives two very different examples of predictions based on this theory: one for the hard and sticky characteristic of highest educational attainment where higher human capital of the future labor force is safely predicted for countries that recently experienced expansions in school enrollment and another for the soft and more volatile characteristic of European identity which shows significant inter-cohort increases that will likely result in a higher future prevalence of a European identity in addition to a national one among the electorate of the EU. This new theory has the potential to finally providing the social sciences with a paradigm with true (quantitative) predictive power for decades into the future.

Acknowledgments

Funding for this work was made possible by the European Research Council (ERC) Advanced Investigator Grant focusing on “Forecasting Societies’ Adaptive Capacities to Climate Change” (ERC-2008-AdG 230195-FutureSoc).

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1 Introduction

This paper introduces a general theory of how societies change as a consequence of the changing composition of its members with respect to certain relevant and measurable characteristics of people. These characteristics can either change over the life course of people or from one generation to the next. While the former can be analytically captured and described by certain age- and duration-specific transition schedules, the latter changes resulting from cohort replacement can be modeled and projected using standard models of population dynamics.

Building on earlier qualitative work by Karl Mannheim and Norman Ryder - who introduced the notion of "demographic metabolism" - this new formal theory applies the quantitative tools of multi-dimensional mathematical demography to forecast the future composition of a population according to relevant characteristics. In the case of persistent characteristics (such as highest educational attainment) that typically do not change from young adulthood until the end of life, quantitative predictions about the distributions of such characteristics in the population can readily be made for several decades into the future. For other characteristics that tend to change over the life course (such as labor force participation) standard age/duration-specific patterns can be assumed. Hence, unlike other models that are called "theories" but cannot be used to make explicit quantitative statements about the future, this theory of socioeconomic change can make such statements in a way that can potentially be falsified. It can therefore be called a theory with predictive power according to Karl Popper's criteria (Popper 1959).

To avoid misunderstandings from the beginning: This is not a theory predicting individual behavior but rather predicting aggregate level change. It is by its very nature a macro-level theory focusing on the changing composition of a population and hence does not have any micro-level analogue.

It can be called a "demographic" theory of socioeconomic change implying that the inspiration and approach of the theory is demographic but its purpose is not. It is not primarily intended to explain and forecast demographic variables (such as population size, births rates, death rates, migrations and alike) but the goal of this theory is to predict socioeconomic change in a broader sense (ranging from values and religions to skills and productivity of the labor force) using a demographic paradigm. One may think of it in the same way that an economic theory of human fertility tries to explain fertility changes using the paradigms and the toolbox of economics but does not try to explain economic outcomes, only the birth rate. Similarly this demographic theory tries to explain socioeconomic change using the general approach and the toolbox of demography.

The title of the paper uses the notion of "Socioeconomic change". Change here refers to observable aggregate level changes over time in the structure of societies and economies. In particular, it refers to the changing composition of societies with respect to the relative sizes of sub-groups that influence the overall behavior of the system. Change is in this sense the antipode to steady-state or stationarity. The notion "socioeconomic" is used in this paper in a very broad sense as describing the interface between society and the economy and covering forces and variables that matter for both. It is not meant to suggest preference for any specific school of thinking or a particular scientific approach. It is seen as a neutral term to try to describe at the aggregate level what is usually called socioeconomic variables at the individual and household level.

The final notion in the title of this paper is that of "predictive power". What does predictive power mean in the social sciences? A conventional definition of predictive power goes as follows: "The predictive power of a scientific theory refers to its ability to generate testable predictions. Theories with strong predictive power are highly valued, because the predictions can often encourage the falsification of the theory. The concept of predictive power differs from explanatory and descriptive power (where phenomena that are already known are retrospectively explained by a given theory) in that it allows a prospective test of theoretical understanding. Scientific ideas that do not confer any predictive power are considered at best 'conjectures', or at worst 'pseudoscience'. Because they cannot be tested or falsified in any way, there is no way to determine whether they are true or false, and so they do not gain the status of 'scientific theory'." (cited from Wikipedia for the key word "Predictive power", January 15, 2012). This strong definition of predictive power leaves much of the social sciences without predictive power because there the focus is typically more on description and explanation rather than prediction (von Wright 2004). However, according to the demarcation criterion of Imre Lakatos (a student of Karl Popper who focused extensively on the social sciences) a theory that fails to make any novel predictions of previously unknown phenomena should be classified as pseudoscience (Lakatos 1978). In the natural sciences this testing of predictions can usually be done by carrying out experiments. In social sciences, where large scale experiments are difficult or impossible to conduct (although there are some "natural experiments"), predictions of the evolution of socioeconomic phenomena over time are the best way to test the predictive power. In the context of the theory considered here the predictive strength of the demographic approach is in part facilitated through the fact that it largely refers to changes in rather inert stock variables with the more difficult to project flows (based on behavior) influencing the distributions only at the margin. Karl Popper (personal communication[1]) actually considered this a great strength of demography as compared to other social sciences.

This paper will be structured in the following way: First I will discuss the writings of Karl Mannheim and Norman Ryder who had earlier suggested that the process of social change can be analytically captured through the process of younger cohorts replacing older ones. This will be followed by a presentation and discussion of the basic propositions of the theory and a description of the multi-dimensional demographic model that is used to model the changing composition of the population over time.. Finally, the broad range of possible empirical applications of this theory is illustrated through two empirical examples from very different domains: The first one reconstructs and projects the changing composition of the population by the highest

level of educational attainment. This is a highly relevant individual characteristic that can be unambiguously measured and is sticky (persistent over the life course) after a certain age. The second example for possible applications of this theory addresses a rather "soft" variable such as the prevalence of European identity in addition to national identity. Forecasting the prevalence of European identity has undoubtedly great significance for the future of the European Union. The paper concludes with a brief outlook discussing further possible applications and important implications of this new theory of socioeconomic change with predictive power.

2 Antecedents: Karl Mannheim and Norman Ryder

Few ideas are entirely new in human history. In a rather general and vague form the idea that societies change as new generations take over is as old as human reflection and one finds early writings on this topic already with the pre-Socratic philosophers and with Confucian philosophy. It is such a plausible concept corresponding so well to everyday life experiences in most families, institutions and companies across all cultures and times that it is indeed surprising how little systematic scientific efforts have been made so far to comprehensively and formally describe this important force of socioeconomic change. While this is true even for the systematic analysis of historical evolutions, it is even more the case when it comes to using this force of inter-cohort change as the basis for forecasting.

When searching through the social science and history literature of the past two centuries, the one strain of writing that seems to come closest to the idea of projecting along cohort lines (the approach proposed here), is the literature on the succession of generations which was prominent in the late 19th and early 20th centuries in history (and even history of art) for explaining the sequence of different historical epochs which, under this view, was driven by the replacement of old generations by new ones with new views of the world, new priorities and new styles. A comprehensive synthesis of this approach was offered by the sociologist, Karl Mannheim, in his 1927 essay on "The Problem of Generations" (Mannheim 1927, 1952). More than a generation later the demographer Norman Ryder published a seminal article in the "American Sociological Review" (Ryder 1965) entitled "The cohort as a concept in the study of social change". Up to this day this article is the key reference for anybody dealing with cohort analysis. Given Ryder's demographic background it is somewhat surprising that this paper is entirely qualitative in nature, even without a single table. And at no point in this paper Ryder refers to the great potential of this cohort approach for not only studying past but also forecasting future social change. Since these writings of Mannheim and Ryder stand out as the most visible and most influential milestones in explaining social change through cohort replacement and hence form the historical basis on which this new theory will build intellectually, the following paragraphs will study them in some detail.

Karl Mannheim was of Hungarian origin and in 1930 became Professor of Sociology in Frankfurt before he left for England, where he taught at London University. His writings are partly in German and partly in English. His work on generations is only one – and during his life time not the most prominent – aspect of his scientific opus. In his essay on "The problem of Generations" (first published in German in 1927) Mannheim starts out by contrasting two opposite views on generations: One that he calls "positivist" and which is focused on measurement and studying the average periods of time taken for the older generation to be superseded by

the new in public life (p. 278). He calls this approach as having a biological perspective which we could safely translate in terms of meaning demographic. The opposite approach, which he calls "romantic-historical", is distinctly non-quantitative and associated with the writings of the German historian, Dilthey. Here the central notion is that of "entelechy" which is meant to be the expression of the "inner aim" or its "inborn way of experiencing life and the world" of one generation. Mannheim seems clearly more amenable to the first view, but his focus was only on looking backwards, trying to understand the forces driving history, rather than looking into the future.

Mannheim defines a generation as being determined by its "social location" (German: soziale Lagerung), something that the members of a generation all share. He compares it to the way one is a member of a specific social class, viewed not cross-sectionally but over time: both generation and class "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". (p. 291). He goes on to discuss what produces generation units and under what conditions a new group of people growing up is sufficiently different from the previous one in order to be called a new generation. This is where Mannheim's sociological approach, which is still to some extent trying to capture the qualitative inner spirit of a generation, is quite different from the more formal cohort approach proposed here, where inner values (entelechy) may be a consequence but not a defining criterion for membership in a generation.

There is one other decisive difference in the proposed new approach to that of Mannheim: Members of a generation (cohort in our case) are not all required to have the same social location, i.e., be similar in key aspects. Quite the opposite, we will consider cohorts as being composed of groups of people with clearly distinguishable properties (which may define social locations) such as speaking different languages, having different levels of educational attainment or different national/European identities, just to mention a couple of the examples that will be given below. Hence, the basic idea is not that generations are homogeneous but rather the opposite, that they are heterogeneous in measureable ways, but that their characteristics are sticky (persistent) along cohort lines and the composition of the properties in the entire population changes as a consequence of the changing proportions of cohorts who are carriers of the relevant characteristics.

More than a generation after Mannheim the Canadian-American demographer Norman Ryder takes up the topic from a more demographic perspective. His seminal 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 (p.843). While individuals pass away, societies become immortal, if reproduction is sufficient to offset mortality. This is combined with his second main thought, namely that this appearance of new individuals provides an "opportunity for social transformation". While for

individuals the flexibility to change over their life time tends to be limited, "the continual emergence of new participants in the social process and the continual withdrawal of their predecessors compensate the society for limited individual flexibility" (p.844). Based on the assumed inflexibility of individuals over their lifetimes he arrives at the strong statement that "The society whose members were immortal would resemble a stagnant pond" (p.844). An important additional thought is, that "metabolism may make change likely, or at least possible, but it does not guarantee that the change in beneficial." (p.844).

Ryder defines a cohort in what has since become the standard demographic 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 cases, birth is taken as the defining event, but this is only a special case of the more general approach. Cohorts differ from synthetic cross-sections (comparing people of different ages at the same point in time) because "time and age change *pari-passu* for any cohort". Unlike Mannheim, Ryder allows for heterogeneity within generations/cohorts. This is also an important feature of the new theory introduced here, in which members of one birth cohort are subdivided into different categories such as groups with different educational attainment. Hence, under this definition a cohort is by its very nature an aggregate measure, i.e. refers to groups of people, or in the words of Ryder: "Thus a cohort experiences demographic transformation in ways that have no meaning at the individual level of analysis, because its composition is modified not only by status changes of the components, but also by selective changes of membership." (p.845).

But in contrast to Ryder's writings this new theory does not necessarily depend on the assumption of complete cohort determinism. The below described tools of multi-dimensional population dynamics do also allow for changes to happen over the life course of cohorts that may either be a function of age or of external period changes (such as the introduction of new technologies that affect all cohorts) and interactions between the two. Hence, the possibility of lifelong learning and changing of cohorts can in itself present a force of socioeconomic change and immortality would not necessarily result in a Ryder's "stagnant pond". To what degree cohort effects dominate over age and period effects is a matter of the specific characteristic studied. In some cases (such as highest educational attainment after a certain age) it is sticky by definition, in other cases this is a matter of empirical analysis for the past and corresponding assumptions for the future.

Inspired by Norman Ryder, I chose the notion of "Demographic Metabolism" as the tentative name of this theory of socioeconomic change because it nicely addresses the very core of the idea: the changing nature of a population through the replacement of individuals with certain characteristics by individuals with others. However, unlike in Ryder's definition the metabolism is not only seen to effect the population in its entirety, but the notion is also generalized to refer to the changing composition of certain sub-categories such as the labor force or the young adult population aged 20-30. This generalization of Ryder's idea will be further discussed in the concluding discussion and outlook section.

3 A Macro-Level Theory based on People as Units

Before we introduce the quantitative forecasting model and give numerical illustrations of specific applications of this theory it is necessary to specify and discuss some basic definitions and assumptions on which the whole approach rests. These foundations of the theory are presented in the form of four propositions.

Proposition 1*: People – i.e. individual members of the species homo sapiens – are the primarily building blocks of every society and the primary agents in any economy. They hence must form the basic elements of any theory of social and economic change.*

In the terminology of the pre-Soctratic philosophers people are the atoms (a-tomos = things that cannot be further divided) of society. Theoretically, one could go further: In a similar way in which modern physics went on to study sub-atomic structures, modern brain research also shows that any decision at individual level is the result of complex interactions among different parts of our brains. But for the purpose of the theory presented here it is sufficient to assume that decisions happen at the level of individuals who then interact with other interactions.

Proposition 2*: For any population its members can be sub-divided into disjoint groups (states) according to clearly specified and measurable individual characteristics (in addition to their age and sex) for any given point in time.*

In principle, any sub-division of people that satisfies the above criteria is legitimate and allows the application of the here described theory. Age is a special kind of characteristic for forecasting because it automatically changes in tandem with chronological time. Hence, the way the following applications and illustrations are designed is to divide the entire population by whatever characteristics are of interest and then further sub-divide all people in this category by age and sex. Over time people can stay in their categories and simply get one year older every calendar year unless they die or move to another category.

Proposition 3: *At any point in time members of a sub-population (state) defined by certain characteristics can move to another state (associated with a change in characteristics) and these individual transitions can be mathematically described by a set of age- and sex-specific transition rates.*

Transitions may not only go to another state inside the system but also to an absorbing state (death) or to outside the system (out-migration).New individuals arriving (through birth or in-migration) will be instantly allocated to one state within the system.. Not all transitions among a given set of states may be possible. Sometimes transitions are only possible in one direction such as from lower to higher educational attainment categories or from the single to the married state from where people may move on to the divorced or widowed state, but cannot move back to the single state.

Proposition 4: *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.*

Human history offers many examples of very significant changes of entire cultures, economies and technologies as a consequence of the changing composition of populations. Most radical were the changes in the dominant characteristics among populations resulting from mass migrations combined with differential mortality. We may think of the end of the Roman Empire or the Spanish conquest of the Americas in this way: new people came bringing with them their very different ways of thinking, acting, and using technologies (characteristics) and replaced the previously dominant characteristics, thus causing radical social change. In such major transitions one may assume that not many individuals actually changed their characteristics over their life courses, i.e. made transitions to entirely new forms of behavior. Rather the holders of the old characteristics disappeared (through being killed, carried away by new diseases or outmigration) and were replaced by new arrivers and their offspring, a radical form of demographic metabolism. In some cases the surviving children of the holders of the old characteristics were also socialized to carry the new characteristics, thus creating a new and different society with the prevailing new characteristics through intergenerational change. Early efforts to assimilate aborigines in Australia were explicitly based on this strategy. On the other hand, existing characteristics can also be lost over generations without such major discontinuities. This is true for the abilities to speak many languages, that have simply died, and for exceptional artistic skills. The artists creating the famous bust of Nefertiti around 1350 BC were part of a school of artists that had skills of producing lively images that afterwards were lost (through a lack of reproduction of such characteristics for whatever reason) until around three millennia later Renaissance artists approached this level of realism again. The history books are full of examples of this sort that can also be viewed as a consequence of the changing composition of the populations with respect to certain such characteristics which also include the abilities to use certain technologies.

The choice of what is a relevant characteristic that is worth studying with respect to its changing distribution in a society can only be context specific. In a way all human beings are different and, in particular, when it comes to mind settings and identities no two people are identical. Hence, the definition of relevant sub-groups depends on the questions asked. In the second part of this paper I will give several empirical examples for using this approach to address specific questions concerning future socioeconomic change but before doing so, I will briefly present the methodological tool to carry out such forecasts.

4 The Multi-Dimensional Cohort-Component Model

Most demographic methods deal with the transitions of people from one state to another over a certain time interval and are in one way or another based on the life table. In its most fundamental form these two states are being alive and being dead and the life table was constructed on the basis of age-specific mortality rates to answer the question of what is the probability of surviving to age x and what are the remaining life expectancies at any given age. Early in demographic history these tables were calculated separately for men and women because observed age-specific mortality rates tended to differ substantially. Aside from this differentiation by age and sex conventional demography still mostly considers populations to be homogeneous, i.e. that for example all men aged 50-54 are exposed to the same risk of death. In the multi-

state case this restriction is relaxed and mortality rates can differ for sub-groups as defined by further characteristics.

The cohort-component model has become the dominant way of projecting populations. While a simple exponential growth model only considers changing population size as a function of the growth rate, the cohort-component model can deal with irregular age distributions and the differential impacts of fertility, mortality and migration patterns on future age structures. The one-dimensional cohort-component model starts with a population stratified by age and sex and then projects cohorts by advancing their age t years over every time interval of t years while at the same time exposing them to assumed age- and sex-specific schedules of mortality and migration and the female cohorts to age-specific fertility rates. Since fertility, mortality and migration are the three fundamental components of population change, this model of projecting along cohort lines is called the cohort-component model. In the multi-dimensional case the population is further sub-divided along additional characteristics. Since the origins of the multi-state model lie in regional population studies, these additional divisions were initially sub-regions, e.g. provinces or states of one country. This explicitly heterogeneous population is then projected into the future by simultaneously considering different fertility, mortality and migration schedules for the individual states as well as transitions (migrations) among the states. More generally, states can also be defined by other criteria such as marital status, labor force participation and highest educational attainment.

The simple cohort-component model goes back to Cannan (1895). Later it was formalized and widely applied by Whelpton (1936) and Leslie (1945) who also gave the Leslie Matrix its name. Since the detailed formal presentation of this model is given in any standard demography textbook (e.g. Preston et al. 2001) there is no need for a formal description here. The multi-state model is based on the generalization of the simple life table (single decrement table) to the multiple-decrement and increment-decrement life tables (Rogers 1975, Schoen and Nelson 1974, Keyfitz 1985). Essentially they describe movements of people that can go back and forth between more than two states. These methodological advances which happened during the 1970s at and around the International Institute for Applied Systems Analysis (IIASA) let naturally to the multi-state population projection model which can simultaneously project the populations of different categories (states, regions) which have different fertility, mortality and migration patterns as well as movements among the categories. Again, the methodology need not be formally described here since it is extensively documented elsewhere (Rogers 1975, Keyfitz 1985, Keyfitz and Caswell 2005, Rogers and Willekens 1986). Here it suffices to say that the methodology is based on the Markovian assumption that the probability of transition to another state is only defined by the presence in the current state in addition to age and sex. In other words, all persons of the same age and sex in the same state have identical risks of dying or moving to another state irrespective of their earlier transition histories. Typically, this assumption is not considered very restrictive, but if it turns out to be a problem for a specific application then one option is to increase the state space and group persons with different histories into different categories.

After the initial focus on regionally defined states, applications were soon expanded to the analysis of marital status transitions (Schoen and Nelson 1974), the analysis of labor force participation and working life tables (Willekens 1978), the

analysis of health and morbidity (Manton 1988) as well as family status cross-classifying marital status and number of children (Lutz 1989). The application of the multi-state projection model to education was to my knowledge for the first time used in the context of an interdisciplinary in-depth systems analytical study of the complex population-development-environment interactions on the island of Mauritius (Lutz 1994).

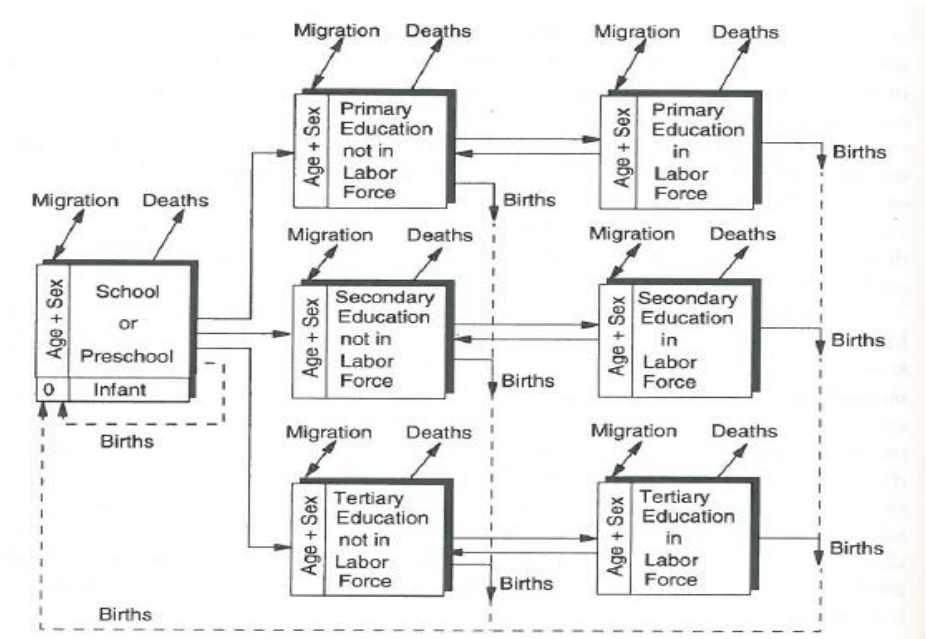

Figure 12.2. Basic structure of the population module with seven states for women. For men it is identical except for births.

Figure 1: A multi-dimensional projection model cross-classifying the population by age, sex, level of education and labor force participation (taken from Lutz 1994, p. 226)

In the model developed for this case study on Mauritius the entire adult population is sub-divided into six states as defined by the cross-classification of three education categories (primary or less, secondary and tertiary) and labor force participation (see Figure 1). The children and in-school population constitute a seventh state. The chart also depicts all the essential transitions of the multi-state model: new births enter the category of child population which advances one year in age every calendar year and is simultaneously exposed to assumed sets of mortality and migration rates. At a given age then all children move on to become members of the adult population not (yet) in the labor force and according to their highest educational attainment. In adult age people can move back and forth between being out of the labor force and in the labor force and age one year every year within their respective categories being always exposed to age-specific mortality and migration risks which are status-specific. The female population of reproductive age is also exposed to assumed age-specific fertility rates – which differ by status – resulting in the births that then enter the model.

While the chart in Figure 1 gives the structure of one specific model, it also shows the general design of a multi-dimensional demographic forecasting model. The following illustrations of other applications will only differ from it in their specific definitions of the state space and the possible transitions among states.

5 Modeling the Dynamics of Changing Educational Attainment Distributions by Age and Sex

The above described multi-state model is most easily applicable in the sense that it requires the least assumptions for studying characteristics that are sticky, i.e. rather persistent over the individual life cycle. Highest educational attainment is one such characteristic which is typically attained at younger ages and then maintained throughout life. While this is almost entirely the case for primary and junior secondary education, the completion of tertiary education can also happen later in the life cycle. Since for many countries good data on the timing of transitions to higher levels of education exist, the age-pattern of education transitions can be appropriately modeled and taken into account.

This stickiness of educational attainment over age becomes particularly visible when looking at the educational attainment distributions by age for countries that recently experienced significant increases in education. Figure 2 shows the education and age pyramids for South Korea as reconstructed and projected using the model of multi-dimensional population dynamics. Here, the education dimension has been added to the conventional age pyramids through color (shading) with the following four educational categories: red- never been to school, yellow- some primary education, green- completed junior secondary education, blue- completed first level tertiary. These 60 years of improvements in human capital in South Korea reflect probably the most rapid and most impressive expansion in education in human history so far. While in 1960 the majority of the female population above age 20 had never been to school, 30 years later in history (in 1990) the population below age 50 already has near universal secondary education, whereas the cohorts above age 50 remain very poorly educated. By 2020 most of the uneducated older cohorts will have died while young women in Korea will be among the world's most educated with almost half of them having completed college. By then the demographic metabolism at the population level will have fully run its course and Korea in 2020 will be a different society and economy than it was in 1960 in almost every imaginable dimension.

The data plotted in Figure 2 come from a major ongoing project carried out by the Wittgenstein Centre for Demography and Global Human Capital (a collaboration between IIASA, the Austrian Academy of Sciences and the Vienna University of Business and Economics) to reconstruct and project 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). While the reconstruction part uses the past age and sex distributions as given by the UN Population Division and therefore only needs to consider differential mortality (and where possible migration) by level of education, the projection part also includes education-specific fertility rates.

This reconstruction of the attainment distributions by age and sex also produced a unique new data set which is superior to other existing data sets of the past (Barro and Lee 1996, Dela Fuente and Domenech 2006, Cohen and Soto 2007, Benhabib and Spiegel 1994) in at least four dimensions : (1) because of its detail (four educational categories for 5-year age groups of men and women) for more than

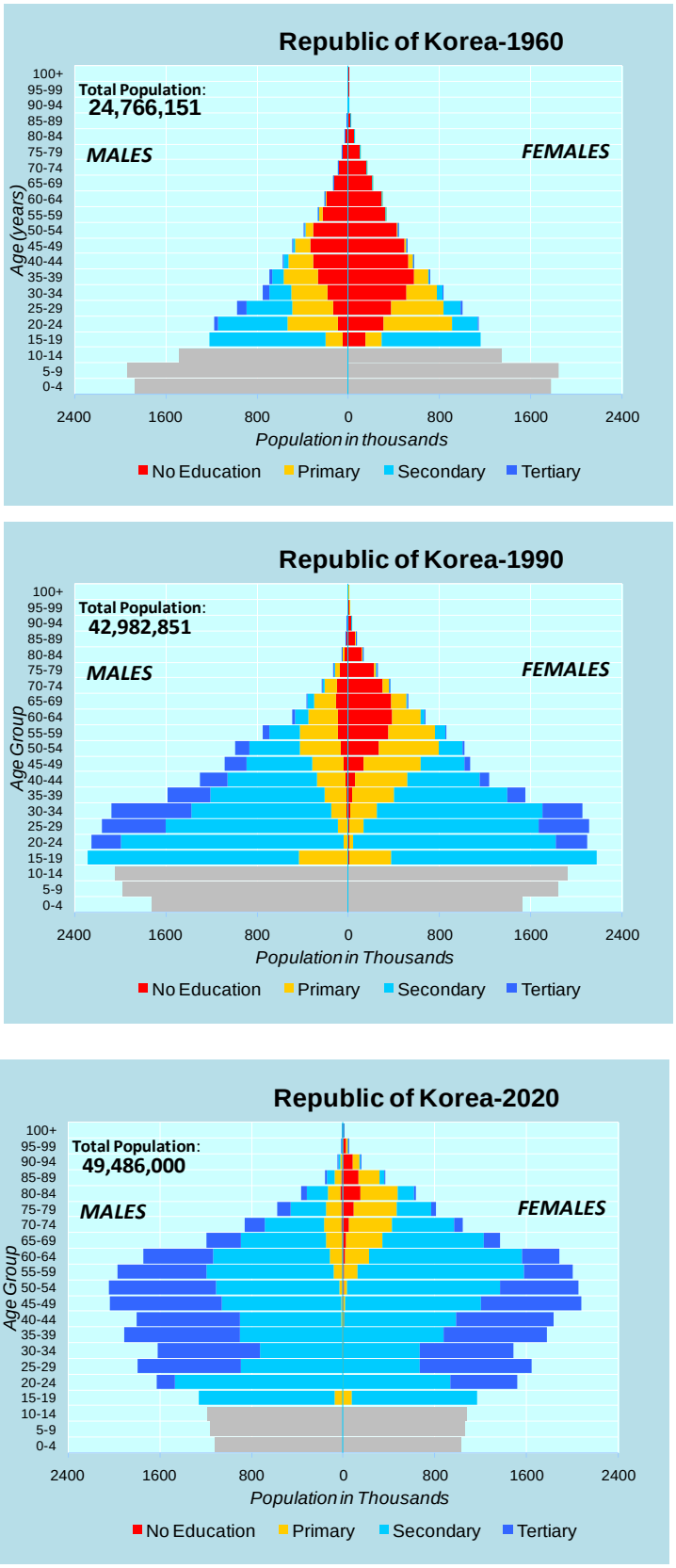

Figure 2: Age and education pyramid South Korea 1960-2020 with colors indicating different educational attainment categories.

120 countries comprising 98 percent of the world population, (2) because of the consideration of differential mortality by level of education, (3) because of the strict consistency of the definition of educational

categories over time, which is a major problem in empirical historical data sets, in which the underlying educational definitions often change, and (4) because of its natural extension to forecasting.

These new data have already formed the basis for a reassessment of the global empirical evidence with respect to several important aggregate level returns to education (Lutz and KC 2011). While there is little doubt that education has an important positive effect on individual earnings the evidence on aggregate-level economic growth has been more ambiguous so far (Becker 1993, Barro and Sala-i-Martin 2003, Benhabib and Spiegel 1994, Pritchett 2001). However, these studies were only based on the best so far available data using typically the mean years of schooling of the entire adult population above age 25. As Figure 2 clearly illustrates for Korea e.g. in 1990 this crude indicator averages the human capital of the elderly uneducated cohorts with that of the highly educated young ones. As a result, this crude indicator has little statistical signal in its change over time and does not correlate strongly with the increase in economic growth which in Korea took off when the better educated cohorts entered the young adult ages. A recent study estimating economic growth regressions using the above described new age-specific human capital indicators found consistently positive and significant effects of educational attainment on economic growth (Lutz et al. 2008). Because it also included the full educational attainment distributions (and not just mean years of schooling) his study also could show that for the poorest countries it is essential to complement primary education with broad based secondary education in order to boost economic growth. This also has a stronger effect on poverty eradication than focusing on tertiary education in an otherwise largely uneducated population.

Beyond economic growth, this new data was also used to reassess at the aggregate level the returns to education on a broad range of outcomes from population growth and health to quality of institutions. For instance, it could be shown that the time when large cohorts of better educated men and women enter the young adult ages plays a key role in the transitions of societies to modern democracies, as assessed through an analysis of global time series (Lutz et al. 2010).

As shown in the case of South Korea, the multi-dimensional demographic approach with a focus on age, sex and level of education can provide a portrait of key dimensions – if not the single most important dimension – of the phenomenal socioeconomic change that Korea experienced over the past decades. Starting in the 1940s and -50s in a situation of abject poverty – worse than many Eastern African countries at the same time – and a setting in which more than 80 percent of the population received no schooling at all, a massive expansion of schooling at the primary and then secondary level resulted not only in a strong fertility decline (complemented by an effective family planning program) but was also a necessary condition for the stunning rates of economic growth that followed. While human capital alone may be not sufficient and effective governance and the right macro-economic strategies are also important, it is hard to see how Korea and the other Asian tigers could have had this economic success without the underlying changes in human capital that facilitated the transformation from agriculture to industry and the associated gains in productivity. As the Figure 2 clearly illustrates, this change happened along cohort lines where in each relevant age group (such as the younger working ages) the demographic metabolism was the major engine of change One could even go further and say that an informed

observer of developments in Korea around 1970 when this major education expansion was already far advanced could have predicted the dramatic subsequent changes in the socioeconomic development of the country would he/she had this new theory at his/her disposal.

Moreover, the rapid improvement in the education particularly of younger women brought fundamental changes to Korean family structure and society in general. The Total Fertility Rate declined from around 6.0 in the late 1950s to around 1.2 today. This dramatic change is also visible in the changing age structure as depicted in Figure 2. Korea is facing massive population aging. It is not yet clear to what extent this will pose a problem in the context of the fact that the young generations are among the best educated in the world which will not only imply higher productivity but also likely result in much better health at higher ages and a later age at retirement. While these specific economic consequences of aging cannot be readily forecast by this new theory of social change (partly because they have no precedence in human history so far), the fundamental underlying forces of ageing and changing characteristics along cohort lines can well be forecast with high certainty. These forecasts are likely to be more accurate and more relevant than those of most macro-economic models over a similar time horizon.

6 Predicting "Soft" Variables such as Preferences and Identities

The other example of the theory presented here comes from a field that is both highly contentious and highly political and is usually considered beyond the reach of quantitative modeling, not to even mention forecasting. It will discuss the results of a recent study using the multi-dimensional demographic approach for predicting the future evolution of European identity among EU citizens. The following description of this study heavily draws on its publication in Lutz et al. (2006).

Many political observers of the current economic crisis and its effect on the Euro as well as the future of the European Union expect a revival of nationalism in many member countries and as a result a possible break-up of the EU. It is often argued that already existing economic interdependencies (particularly in the banking sector) are the main force that still holds the EU together. These people forget to consider the changing opinions and identities of the European citizens, the people who make up Europe.

Scholars in political science tend to think that the question of identity is crucial for the legitimacy of any political system (Easton 1965). In this view the future of the European Union primarily depends on whether or not the European citizens (the demos of Europe) have a European identity or not. Furthermore, recent work stresses the view that people usually have multiple identities which do not necessarily compete with each other. In this view European identity complements but does not displace national and regional identities (Risse 2000). Naturally, the European Commission is interested in this issue and has for long collected information on it in the Eurobarometer surveys (EB). 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 identical wording more than a dozen times in the EU-15 (members of the EU as of 1995) with national samples of around 1000 in each round.

In 2004, 42 percent of the adult population above age 18 of the EU-15 said that they felt themselves to be solely nationals of their own country, while 58 percent gave an answer which reflected multiple identities including a European identity. As Figure 3 shows for the empirical data for 1996 and 2004, there is a clear decline in multiple identity with age. The older the respondent, the higher the chance that he or she will feel 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.

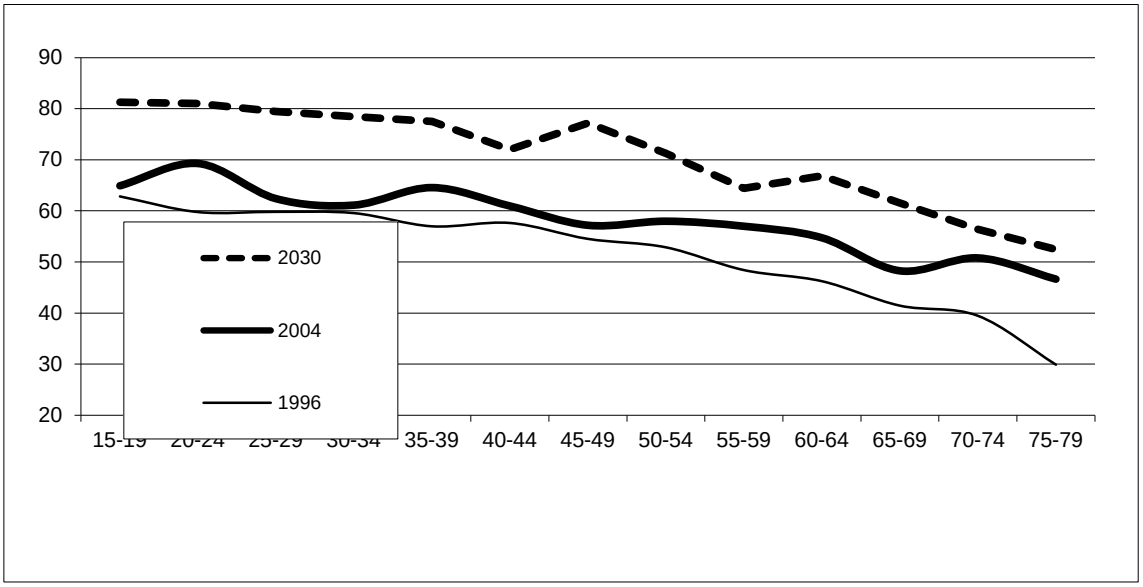

Figure 3: Proportion of the European population with multiple identity (including European identity) by age, 1996, 2004 and forecast to 2030.

Does this pronounced age pattern imply that as people get older they tend to have more of a national identity only and give up multiply identities they might have held earlier? In this case of a dominating age effect, the significant population ageing expected for the coming decades would imply a decline in the proportion of citizens with multiple identities. Yet, the same pattern could also be explained in terms of a cohort effect: young cohorts are being socialized in a way that they have higher prevalence of multiple identities than the previous cohorts from a young age on which they then maintain throughout their lives. This force would result in significant increases in future European identity through demographic metabolism (the younger more European minded cohorts replacing the older ones).

Both of these contradictory interpretations are possible and based on one cross-sectional survey alone their validity cannot be assessed empirically. Only panel data, i.e., age profiles at different points in time, allow us to discriminate between age and cohort effects.

Lutz et al (2006) carried out statistical analyses showing a highly significant positive cohort effect. The resulting coefficient of 0.48 means that for cohorts born one year later, the proportion with multiple identities is on average half a percentage point higher. This confirms the view that the change towards more multiple identities in the European Union largely happens along cohort lines, i.e., cohorts born later in time are

socialized in such a way that they adopt fewer solely national identities, and more multiple identities. They then largely maintain these identities throughout their lives.

Since expressed national versus European identity can be viewed as a characteristic of individuals meeting the above defined criteria, its changing prevalence in the population can also be modeled and forecast using the multi-dimensional model introduced here. Doing so Lutz et al (2006) forecast the future trends in the degree of multiple identities in Europe under the assumption that the estimated cohort effect remains effective over time. In other words, they incorporate the assumption that in each subsequent cohort the proportion with multiple identities increases by 0.5 percentage points and remains stable along cohort lines. The top line in Figure 3 gives the resulting predicted age-specific proportions with multiple identities in 2030, and shows a marked upward shift. In terms of absolute numbers the results show that in 2030, there will be only 104 million adult European Union Citizens (EU-15) who have strictly national identities, while there will be 226 million with multiple identities. This study also suggests that very strong country differentials are likely to persist, but on average in Europe, the relentless forces of cohort replacement by which the older, more nationally-oriented cohorts will die and the younger, more European-minded cohorts will take their place, are likely to bring about significant changes in the pattern of European identity. These predicted tectonic shifts in European identity are likely to have significant longer-term implications for the more fundamental political and economic developments in Europe, while short-term politics and market reactions are likely to continue in a volatile manner. With view on the current political debate in Europe and the well established centrality of national/European identity for the legitimacy of institutions, this study can lead to the conclusion that most commentators and analysts miss out on referring to one of the most important forces that can likely lead to more European integration in the future, namely the demographic metabolism that will replace predominantly nationalistic cohorts through younger ones that predominantly also identify with Europe.

If the theory of socioeconomic change introduced in this paper can produce quantitative forecasts for issues that are as soft and qualitative as the notion of national/European identity, it can also effectively be applied to forecasting the future prevalence of a large array of personal views, opinions, preferences and values. The only precondition for the applicability of this theory is the availability of data that allow a clear discrimination between the different categories of the characteristics studied and the establishment of the existence and strength of a cohort effect as well as information on age/duration-specific transition rates.

7 Discussion and Outlook

Virtually every existing population of humans can be meaningfully subdivided into groups whose members differ from each other according to measurable characteristics which also matter for their behavior. If membership in these groups is stable over the life course after a certain age (such as ethnicity, native language, highest educational attainment or stable values and identities) or shows patterns of transition that can be modeled based on plausible assumptions (such as marital status, labor force participation, income group, health status etc.) then the multi-dimensional demographic approach allows us to model how societies change over time as a function of the changing relative sizes of these sub-groups. I do not know of any other theory in the

social sciences that has potentially greater predictive power over decades into the future than this one based on demographic metabolism.

Many open questions remain. Some of them will be mentioned in this concluding section and some will be elaborated in subsequent papers. The main purpose of this paper is to put this comprehensive new theory of socioeconomic change on the table for the first time; further elaboration will be needed both on the formal and on the substantive side.

One key issue that requires significant further elaboration is the question of how to deal with uncertainty in the context of prediction. Over the past two decades an extensive body of literature on probabilistic population projections has developed (Lutz and Goldstein 2004, Lee 1998). These approaches that replace point forecasts with ranges of explicitly stated uncertainty can, in principle, also be applied to the kinds of multi-dimensional forecasts presented here. The main practical problem is that the uncertainty distributions need to be established for a much larger number of input parameters and there often is not much of an empirical basis for grounding these assumptions. Yet, the more serious issue lies is of a more theoretical nature and relates to the possibility of falsification of probabilistic statements. Under a probabilistic view the probability of actually realizing a precise point forecast is practically zero because it almost certainly will be somewhat higher or lower. This same problem arises with most predictive theories in the natural sciences. Nobody would expect a precise point prediction over decades into the future. On the other hand, too broad uncertainty intervals are also unsatisfactory, since they do not offer enough information and are difficult to falsify. As the question of falsification of probabilistic statements is one of the big and complex issues which seem to be still largely unresolved in the theory of science literature (Pearl 2000), it would not be specific for this theory of demographic metabolism. However, since this is one of the few social science theories which claim to have predictive power, it is certainly worthwhile to further discuss this question in a specific social science context.

The space in this paper only allowed for the description of two examples of predictions based on this new theory of demographic metabolism. But these two already show that this concept can be operationalized in a practical and meaningful way resulting in new and relevant information about the future that was not available before. As discussed in the introduction, these novel predictions of previously unknown phenomena correspond precisely to the criterion that Imre Lakatos (1978) gave for distinguishing a good theory from "pseudoscience".

The examples given also illustrate that the theory is applicable to almost any other meaningful and measurable sub-division of the population and even for cases in which the persistence along cohort lines is more questionable and becomes a matter of empirical assessment.

This demographic theory can possibly bring innovation not only to sociology but also to economics. Demographers tend to use many sociological and economic concepts in their work. Why should not a genuinely demographic concept, applied far beyond the traditional realm of demography also prove to advance thinking in those other disciplines. While for sociology and the study of social change the applicability of this theory is fairly clear – it was not a coincidence that Ryder published his seminal paper in a leading sociology journal –, there are many relevant aspects for economics as well.

Wherever in economics the almost ubiquitous assumption of strictly homogeneous human agents is considered as too strong this model offers a quantitative way of explicitly addressing this heterogeneity: this can range from distinguishing between groups of people that have different sets of indifference curves underlying their choices to groups of people with different discount rates in their assessment of utilities to people that have different degrees of rationality in their behaviors.

Finally, it should be stressed that the innovative aspect of this paper does not lie in the methodologies of multi-dimensional mathematical (multi-state) demography or in highlighting the importance of changes along cohort lines-both have been well established in the scientific literature for the past 40-50 years, although they tended to remain at a lower level of attention. The new feature of this paper is the combination of these elements in a way that forms a comprehensive theory of socioeconomic change with quantitative predictive power. To my knowledge no other comprehensive theory with such properties exists to date. If accepted and further corroborated, this theory can bring a major paradigm shift in the way socioeconomic change is viewed, analyzed and forecast with direct implications for policy decisions and choices made today at the level of individuals, companies and societies.

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Notes

[1] To my knowledge, Karl Popper has never explicitly written about demographic theories, but thanks to his desire to eat his favorite dish (Wiener Erdäpfelgulasch = Viennese potato goulash), I had the opportunity to have a lengthy discussion with him about this topic in 1984, when I stayed in London for an internship with the World Fertility Survey and his private doctor in Vienna asked me to deliver a larger number of packs with his favorite dish to him. In return for this service, he talked to me at his private residence, patiently answering the questions of an eager young demographer with an interest in philosophy of science. In essence, what he told me about the role of theories in demography was: With respect to the validity of theories, demography is not different from all the other sciences. But through its quantitative nature it should be actually easier than in many other social sciences to define hypotheses and theories that are specific enough so that they can be tested, i.e. potentially falsified. He also asked what would be the most important theories with predictive power in demography. After some hard thinking I could only come up with the theory of demographic transition which predicts that all societies starting from pre-modern conditions will experience a fertility decline following the mortality decline. Despite its lack of precision about the time lags involved and the precise course of fertility decline, this theory has predictive power and as a consequence underlies all the population projections for developing countries where further fertility declines to at least replacement levels are being assumed. After listening to my explanations with interest, he then asked whether demographic models could be applied to forecast other social trends as well, in particular utilizing the great inertia of population changes over time. Since I had never thought about it in this way, he encouraged me to do so. And it took me over 25 years to finally take up the challenge.

(I remember well his last words as we waited for the taxi outside his house which would bring me back to the train: "As scientists we have to be like bats, sending out signals to an unknown world and based on the echoes we receive, build an image (theory) which is the basis for predictions where we can safely fly. And as we fly, we have to listen very carefully to be able to update our predictions". Looking back, I remember that he had particularly big ears.)