DEMOGRAPHIC TRANS-, INTER- AND MULTIDISCIPLINARY MODELS

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Abstract

Contemporary demography is placed under the essential sign of trans-, inter- and multidisciplinary changes and harmonization, in both its body and the integral spirit of its scientific models. The classical demographic pattern or model typical of the eighteenth century, derived from Johann Peter Sussmilch, was substituted in the twentieth century in an almost exemplary form of the model of favourable demographic transition, which eventually became unfavorable throughout Europe, and implicitly in Romania. The new demographic models, which start in an attempt to explain the mutations of birth and mortality, but more especially of fertility, aging and migration, cannot maintain the old isolating and unidisciplinary mark, allowing access of the flourishing evolution of trans-, inter- and multidisciplinarity modeling.

Keywords: demographic model, trans-, inter- and multidisciplinary model, demographysical model, fractal demographic model, imago-magistic model.

1. A conceptual and historical sketch of the classical demographic model

The demographic model represents a twofold conceptualization with parallel histories, that of the model (and modelling), and implicitly that of demography. The classical demographic model remains imprisoned in the standard meaning of a scientific model, that of a theoretical or material system with which one can indirectly study the properties and the transformations of other, other real and complex, other system – with which the first system has at least one point of analogy.

Any scientific modelling approach has minimally two major goals, one theoretical, aiming at simplifying the reality investigated with a purpose of knowledge, simulation and forecasting, as well as a pragmatic one, i.e. the concrete construction of the model, followed by testing and validation/invalidation; any modelling defines a continuous, iterative and innovative process, which turns the model into an essential element of the triad constitutive of science, and gradually substitutes the method in many of the most pragmatic pursuits (theory-model-phenomenon or real process as a subject of study). The first use of the concept of model belongs to Eugenio Beltrami, who managed, in 1896, to build the first model (the Euclidean model of non-Euclidean geometry – as geometry was the science that intuited and first defined models as tools for the study of a field, phenomenon or object that was inaccessible to direct research).

The concept of classical model, whatever its mental or experimental nature, had a direct relationship with the form of thought that develops it, as human thought reproduces and combines concrete ways of existence and manifestation of the surrounding reality, as can be seen in Leonardo da Vinci's paradoxical synthesis in *Macchine per volare*: *"a bird is an implement that works in accordance with the laws of mathematics, an implement which humans can reproduce in all its movements"*.

The demographic model brings together three models with similar histories or with a parallel development: the population model, out of which also emerges that of the human population, mathematical model and the statistical model. The population classic model, approached as a biological generalization of "growth and regulation of the various vegetable and animal populations, also tracking and interactions between populations, from competition to conflict" (McArthur, Connell, 1966), once restricted to the human population, is to be consistent with the mathematical one, dedicated to objectively explaining *"the manner in which the micro-components and the interactions between them, interpreted individually or grouped into subsystems, generate and explain the whole of the system"* (Octav Onicescu and the model of informational energy), through a *"non-contradictory definition and description of a number of processes and phenomena"*, the theses, postulates and axioms, as well as their logical-mathematical corespondence; and, finally, it turns to the stage-built concept of the statistical model, as a necessary link within an integrated process of knowledge, consisting of a hypothesis, a schematic representation of a process (phenomenon), statistical testing of the assumptions made on the reality, and resumption of the process in a general theory (Săvoiu, 2013). What the result of this combination of models, in various proportions, generates is nothing but the classic demographic model.

The term "demography" was proposed to define a distinctive science about human population in 1878, at the Second International Congress of Hygiene, by Emile Levasseur, quickly replacing the older designations of "social statistics or physics" or "theory of population", there are conceptual and Demography already existed, and had turned more than two decades from its inception, in the 1855 work of Achille Guillard titled "*Eléments de statistique humaine ou démographie comparée*". John Graunt, considered to be the first demographer and statistician, who also discovered the first regularities and uniformities of a demographic and statistical type, revealing the possibilities of predicting demographic trends, along with Karl Neumann, who collected data concerning the city of Breslau, including the age of the deceased, and sent them to Leibniz, and astronomer Edmond Halley, who used those data to achieve the first table of populational mortality, and especially Johann Peter Sussmilch, through his work "*Die göttliche Ordnung*", published in 1741, contributed to the empowerment of demography. If, in the year 1600, Sir William Petty predicted a first crisis linked to the overpopulation of the world for the year 2600, based on land area then known and the space individual requirements, estimated at about three acres per person, in 1700 the systematic thinking of Prussian Johann Süssmilch estimated, with great accuracy at the time, a world population of one billion inhabitants, identifying and formulating an interesting link between the increase of the population numbers and life expectancy, and thus demonstrating the precision of the models of the new science. The concrete stages of a classical demographic modelling are: a) structurally defining the demographic system (isolating the specific phenomenon, from birth rate, mortality, fertility, marriage or divorce rate, up to aging or employment of the population, formulating the questions, identifying the variables of major interest); b) formulating the preliminary model based on sets of assumptions/hypotheses and conclusions regarding the variables, parameters, relationships between variables, etc.; c) collecting the relevant empirical data; d) estimation of parameters and functional forms; e) preliminary (gross) statistical testing of the demographic model; f) further testing of the demographic model (based on the new data); g) decision – accepting or rejecting the set of assumptions, in conditions of the the predictions complying or not with the demographics that became available in the meantime; h) validation or invalidation of the demographic model by means of theoretical generalizations, prognosis methods or subsequent simulations. In-between classical and modern models, there appeared a few models of the demometric or mathematical-demographic type with obvious trans-, inter- and multidisciplinary trends. The demometric model, in keeping with the term coined by Swedish demographer Hannes Hyrenius in 1966, and borrowed, after 1969, by another famous demographer, Austrian Wilhelm Winkler, to extend its use, describes human population statistically and mathematically – or in an abstract manner, studies the relationships of a functional nature between demographic phenomena, analyzes the interdependencies between the demographic factors and the demographic changes, making use of statistical and mathematical methods of analysis, alongside mathematical models, in order to interpret population dynamics and achieve short-, medium- or long-term population projections. Just as economics is recovered, through the statistical and mathematical excess, in econometrics, biology in biometry, sociology in sociometry, psychology in psychometry, demography, dominated by mathematical methods and models of analysis, naturally becomes demometry.

There also coexists a variation of a purely mathematical demographic model, which applies only mathematical methods and describes, in an exclusively mathematical way, in a multifactorial manner, population flows, as well as its structural dynamics and its states and conditions. Among the most important modelers of that demographic-mathematic universe, one can mention, alongside its founder, recognized as the originator of the theory and model concerning the "stable population", i.e. James Alfred Lotka, some other reputed American demographic like Ansley Coale, Nathan Keyfitz, and the notable representatives of the French demographic school, whose contribution was special, such as Alfred Sauvy, Louis Henry, Jean Bourgeois-Pichat and Roland Pressat.

The architecture of trans-, inter- and multidisciplinary modelling capitalizes on the following major principles: a) minimum simplification, through assumptions/hypotheses, or the existence of a minimum of unrelated sentences and unproven sentences (between two interpretations of a demographic phenomenon, the interpretation that is preferred is the one having with the fewest assumptions or simplifying hypotheses); b) the simple alternative (very complicated demographic models failed to yield categorically better results than simple extrapolation formulas); c) the value certified through dialectical reasoning (the model facilitates discussion, clarifies the results and limits the errors of judgment); d) the cultural component (if humans' economic and social actions were independent of their cultural inclinations, the enormous variability of the demographic pattern, depending on time and place, could not be explained in any way); e) shifting from one- to trans-, inter- and multidisciplinarity through successive models (improvement by imitation, analogy and transitivity from one type to the next).

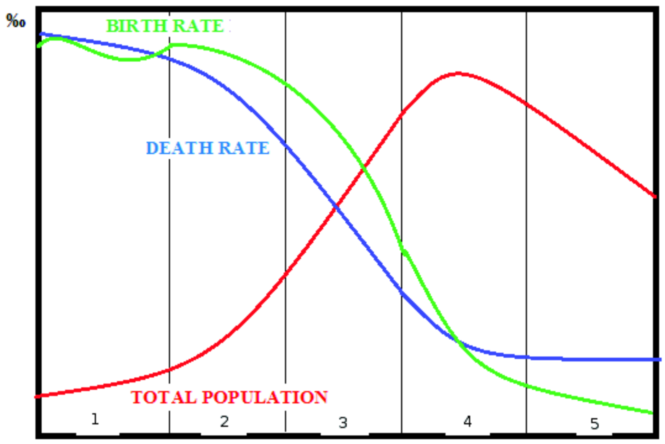
A brief history of the major demographic models invariably starts from the Malthusian model.

In a summarized form, Malthusianism argued that population grows in geometric progression, whereas the volume or mass of livelihoods grows in arithmetic progression, and this imbalance, once generated, requires intervention through obstacles of an obviously regressive nature and purpose to regulate the relationship between "population and livelihoods". Malthus found, in accordance with his demographic model, that the number of human population doubles every quarter of a century, so the population number is historically and objectively limited by the concrete potential of subsistence, and the size of the population increases inevitably where the concrete potential of subsistence increase, unless the demographic increase is restricted by obstacles that are strong and really manifest (repressive or preventive). In the Malthusian model, ethical restraint defined the only preventive obstacle, while vice and suffering, caused by famine, epidemics, disasters and wars, formed the main repressive obstacles. Moral restraint, a Malthusian panacea, was described in various forms, from delaying marriage to choosing abstinence until marriage as a solution virtually opposite to marriage. Malthus's essay about the law-like character of population growth led declaring demography as a "frightening science", being enlightening as to the deeply apologetic character of his controversial model, which, in the late eighteenth century, demonstrated that the human population was subject to a potential increase that was puts at risk the amount of food, leading to increased hunger and poverty. While the Malthusian model was rather simple, later Gompertz and Verhulst produced complex demographic models.

The most enlightening or dominant of the demographic models considered classic is still the model focused on the *demographic transition* paradigm, originally founded by two sociologists and demographers, Warren Thompson and Frank Wallace Notestein, and subsequently extended to five phases by biologist and psychiatrist Carlos Paton Blacker. *Demographic transition* is essentially a long demographic cycle of a human population in which one period in its evolution is ascending (favourable at the beginning or in the first three stages of population transition), where the decrease in mortality begins to be followed by declining birth rates, and in the time gap created and defined by the times of occurrence of the two reductions of demographic rates there occurs a visible increase in population, which however, at the end, coexists with their opposite by the same name of *stage* or *phase*, yet having an adverse impact on the number of total population (Figure 1):

Demographic transition stages of phases

Fig. 1



Source: Developed by the authors in accordance with the Thompson–Notestein–Blacker model.

The five stages of the complete demographic transition cycle have distinctive characteristics and dynamics of birth and mortality rates, with an obvious impact in the overall population:

Stage 1 (stationary upper): birth and mortality rates are high, and, on average, relatively equal;

Stage 2 (expansionary outset): mortality rate has a diminishing trend;

Stage 3 (completion of expansion): the diminishing trend of the mortality rate is maximum

Stage 4 (stationary lower): birth and mortality rates are lower, and, on average, relatively equal;

Stage 5 (natural population decrease): birth rate is below the death rate.

Various demographic theories devoted to several significant particular variables focused on the model of demographic transition (or the *Demographic Transition Model* – DTM), and subsequently detailed a number of specific transitions, which, while not giving up population investigation, knowledge and forecasting as a "condominium" (Trebici, 1970, p. 65), substantially restrict the overall demographic reality to a particular substructure or even generalize it: i) the distinctive model of the age structure transition, whose main outcome is an aging population (Burgeois Jean-Pichat); ii) the specific model of marriageability transition (John Hajnal); iii) the model characteristic of the transition of activity rates, with an emphasis on female activity rates (John Durand); iv) the transition model defining territorial mobility (Wilbur Zellinski); v) the model of urbanization transition (Vladimir Trebici); vi) the generalized model of demographic transitions (Dennis Wrong), etc. (Dobrotă, 2005; Săvoiu, 2006). The main limitations of the demographic transition model have been identified and extensively commented, and they remain valid to this day: a) it cannot reveal the impact of other demographic variables, such as migration; b) it fails to consider and specify, or else forecast, how long a country remains in each stage; c) the stages are not necessarily successive, and the final stage can be easily reached; d) it does not describe or provide solutions of survival after the final stage for a human population. In the population estimates for the next decades, the case of Romania, and Europe in general, was placed in phase or stage five.

2. SOME INCREASINGLY TRANS-, INTER- AND MULTIDISCIPLINARY CONTEMPORARY DEMOGRAPHIC MODELS

The main purpose of demographic classic modelling is maintained in the new types of modelling, which are increasingly trans-, inter- and multidisciplinary, it being dominated by an obvious intent to simplify or reduce a multitude of factorial variables (variants or numbers) to only a few initially plausible parameters, subsequently tested and validated, and making possible an approximate substitution of demographic reality, reducing its usual complexity through a process of modelling simplexity (simplification of complexity). The *interdisciplinarity of demographic modelling* has a nuanced goal, involving a concept, methods and general modeling laws common to several disciplines, conducting analysis in contexts as varied as possible, in order to highlight the multiple facets and possibilities of application. By means of the interdisciplinary demographic modelling, horizontal transfer of concepts, methods and laws is favoured, from one science or discipline to another: *practical* or *applicative* transfer, *epistemological* (or cognitive) transfer, and transfer *generating new disciplines* (Niculescu, 2007). The interdisciplinary of modelling is also a process of focusing or concentrating on interstitial issues in several sciences or disciplines. *Transdisciplinarity of modelling* is considered a superior form of interdisciplinarity, which involves concepts, methods, methodology and language that tend to become universal, being generated dynamically by the action of the numerous stratifications of reality (the theory of modelling reality, the theory of modeling information about reality, the theory of scientific modelling of information about reality, etc.). *The multidisciplinarity of demographic modelling* presupposes that the study of, and research into a human population should take place simultaneously from several points of view, descended from the multiplied thinking of several sciences. Demographic modelling and human population investigated or researched in multidisciplinary terms finally come to be enriched through its actual results.

The first early trans-, inter- and multidisciplinary demographic model was that achieved, and especially presented to the public, in the Roman Senate, by Julius Marcus Cicero. In 56 BC, the conservatives in the Senate, unable to directly attack Julius Caesar, victorious in Gaul, staged a trial against a close friend of his, Balbus, a rich immigrant who had come from the Atlantic coast of the Iberian Peninsula. M. Tullius Cicero defended the latter in court, and so his ancestors received Roman citizenship as immigrants from the Volscian city of Arpinum. Cicero's model is in fact a trans-, inter- and multidisciplinary demography-based legal model centred on migration. His entire speech emphasizes this model, stressing that a population that receives immigrants in their midst, as equal members, having the same rights as original population, becomes a stronger population (so, a robust, favourable, upward-aiming demographic model), while a population that does not treat in a similar manner the immigrants who acquire the citizenship, as if they were their own fellow-citizens, is gradually turning into a population exposed to disintegration and destruction (a weak, downward-driven and perishable demographic model).

A special category of trans-, inter- and multidisciplinary demographic models are those of pregnantly sociological nature. Sociology, through its emergence and evolution, led to drastically changing the classic demographic model – and its authors were such as resounding names of demographers, who thus met such other names of outstanding sociologists: Pitirim Sorokin, Philip Hauser, Kingsley Davis, Ronald Freedman, John Caldwell, Judith Blake, John Bongaarts, Paul Glick, Thomas Burch, Louis Roussel, Gary Becker, etc. The trans-, inter- or multidisciplinary connections established between the two sciences, the analogies, translations, imitations, approaches and loans, mutual accommodations and common benefits, led some demographers to attempts at assimilating the models of demography into the body of the models of population sociology. At first glance, society, as the extended study object of sociology, also includes the human population as a subdomain.

As an apparent logical consequence, the demographic model should be embedded into the sociological model, through a process of "sociologizing". This was actually the trend that characterized American sociology, as a result of its holistic or comprehensive integrative approach. Family, households, phenomena such as fertility, marriage, divorce, birth and death (rates), cannot belong to one-disciplinarity, be it sociological, but, naturally, to the many models with demographic trans-, inter- or multidisciplinary reverberations. Cultural anthropology, ethnology, historiography and sociology could only contribute together to the diversification of modern demographic models. The new trans-, inter- or multidisciplinary models detail and emphasize the importance of population growth, household and family formation, dynamics of marriage, family life cycle, the relationship between migration and urbanization, job mobility, etc. Modern demographic models fluctuated in signalling cases of preponderance now naturalistic, now biologic, or social, cultural, economic, thus reviving neo-Malthusianism, but also anti-neo-Malthusianism, through currently reputed models such as *demographic pressure*, *population explosion*, the models of *stationary population* or *optimum population*.

The demographysical models are built in the same trans-, inter- and multidisciplinary logic. Gravity models (or push-pull models) are also consistent with the beginning of migration preoccupations. The volume of a flow of international migration is thus defined as the result of the simultaneous action of the distance and the population of the two areas, that of origin and the intended destinations. Without being basically substantial models, they are still the result of interdisciplinarity between demography and physics, but are still regarded as constructions exclusively based on a collection of repeatabilities and regularities, in the sense of demographic statistics, as gravitational theory considers migration as a factor of spatial balance. The category of the push-pull models predominantly includes those models based on causal economic factors (here Malthusian inspiration is so obvious). The first really demographyical model is John Quincy Stewart's model focused on gravity, approached as a concept of "*social physics*" – which was introduced by the Princeton University astrophysicist in 1947. It is an attempt to use equations and concepts of classical physics – related to gravity –, identifying simplified perspectives and laws of demographic behaviour (i.e. a large number of human beings in a city tend to turn into a force of attraction for other people, who eventually want to migrate there, and the concept of demographic gravity becomes real in the model, along with the force of demographic attraction, demographic energy, demographic force of gravity, potential and gravity gradient, etc., all conceptualized and measured by John Quincy Stewart. The Stewart model quantifies the interaction between two populations (I and J), formulating a law-like rule of the physical (gravity) type, according to which interaction is proportional to the demographic force between urban centres, defined by their population masses (Pi and Pj) divided by the square of the distance between them:

$$Tij = G \times (Pi\ Pj) / (dij)^2 \qquad (1)$$

where G is a demographic constant of a gravitational origin (Stewart, 1948)

The model diversifies and takes over elements of the new schools of quantitative geography, later becoming the demographysical Carey-Stewart-Warntz model, also conceptualized and as a model of human gravity. (Garling, Golledge, 1993; Sen, Smith, 1995).

Other models combine the new geopolitical disciplines with demographysics, and lead to incredibly original solutions. An example of this is the imago-magistic model. Axiomatically, it is supported by several corollaries and exemplified in three territorial cases: Pakistan, Somalia and the former Yugoslavia. The premise of the model is given by the following statement: *for the population in an area with fixed boundaries, social cohesion depends on perceptions resulting from interactions between the members of that population, and cohesion is all the greater as between the members of that population there are more mutually beneficial interactions*.

Corollary 1: *the lower are the interactions among the members of a population in a given territory, the more the perceptions are rendered as stereotypes of a racial, linguistic or historical nature*.

Corollary 2: *the more infrequent the mutually beneficial spontaneous interactions are, the more they will be supplemented by the political factor through social engineering* (Petre, 2015).

The model stresses that if the members of a human community interact within it, and the interactions benefit an ever larger number of them, general prosperity and identity are generated simultaneously. However, when one of the results (common identity or prosperity) is missing, there occur imbalances with conflictive potential.

Demographic trans-, inter- and multidisciplinary models also characterize the current and future delimitations of the development of urban areas. The "cluster" demographic models consider that urban areas develop in a manner similar to the growth of agglomerations of particles in a dimensional system, and such models are placed within an interstice of demography and statistical physics.

A case in point is *model of the limited diffusion agglomeration*, ALD, in fact the first demographysical model applied to the development of an urban area, and which led to a tree-type or dendridic structure of the city, around a nucleus, or a "commercial and administrative center". Essentially, ALD predicts the existence of a single mega-cluster that extends through the peripheral grafting of a new *development unit* – aiming at population, capital, resources (Gligor, 2012). Other models are seeking relevant, credible explanations of densification by exploiting fractals (Frankhauser, 1994), or of regional demographic implosion by making use of cavitation, etc. Demographer and mathematician Kapitsa, and other US and Danish demographers and mathematicians, tried to identify the decisive factors in the development of human community, and found, in both prehistoric and historical times, that it was not economy or work, but *a result of the two, namely spirituality and information, culture in its broader sense* (Săvoiu, 2006).

3. A FINAL REMARK

The demographic perspective of a prompt projection or of forecast iwthin an acceptable margin of error, along with relevant simulation by maximizing (fertility, birth, etc.) and/or minimization (death rate, death-and-birth rate, etc.), but also selectiv scenario-building, permanently updating and criterially and tentatively finding, through as rigorous testing as possible, the solutions of median, pessimistic or optimistic impact, generically define a successful and lasting modelling in demography.

In their essence, the trans-, inter- and multidisciplinary models resulting from the process of modelling, no matter how complicated or simplified they may seem, remain only approximations of the reality of demographic phenomena, intended to temporarily explain the dynamics affected by the residual error of a number of factors, which was initiatially compensated or impossible to explain in relation to the time of their modelling.

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