# *Models of Demographic Behavior*

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## Introduction

The aim of the paper is describe the behavior and dynamic of the European population and to check the popular models of demographic transitions MDT [Thompson, 1929; Notestein 1945] and second demographic transition SDT [Aries, 1980, Korotayev et al, 2006]. The demographic behavior of the world population has always been a challenging topic for statisticians. Although the mathematical-statistical methodology of population projections has enormously developed, the usage of multivariate statistical methods allows seeing the demographical processes from another aspect. In this paper we use several traditional methods of multivariate statistics to reduce the dimensionality of vectors of demographic variables to get more visible picture of demographic processes characterizing demographic transitions.

The second part is dedicated to analysis of demographic tendencies in Europe during the last half-century the period that has been treated as the second demographic transition (SDT) [Lesthaeghe; Lesthaege & Neidert, 2006]. We prove several hypotheses showing that the SDT process runs in different way in different parts of Europe and try to find the reasons of these differences.

As data we use the official data published by Eurostat [*http://epp.eurostat.ec.europa.eu*]. As methodology we use at first a traditional method of multivariate statistics – Factor Analysis (Principal Components method with Varimax Rotation) – the tool that allows compress the data so that the information can be embedded into the space of low dimensionality and hence can be also visualized. The prerequisite for this is the fact that the demographic data are usually numeric and can be considered as continious variables. The second method we apply is Cluster Analysis (K-means with iterations). In data processing the SAS and SPSS software has been used. For testing statistical hypotheses in most cases $\chi^2$-methodology has been applied.

## The data

The analysis is based on the data of Eurostat [http://epp.eurostat.ec.europa.eu/] including data on 42 European countries (see Table 6). The following ten demographic measurements have been used.

1. Crude marriage rate – number of marriages per 1,000 population.
2. Total first marriage rate – probability of first marriage for a person if he or she were to pass through his/her lifetime up to the age of fifty conforming to the age-specific first marriage rates of a given year.
3. Mean age of women at first marriage
4. Crude divorce rate – number of divorces per 1,000 population.
5. Total divorce rate – probability that a married person's marriage will be divorced during their lifetime conforming to the divorce rates that correspond to the marriage duration of a given year during their fertile years.
6. Crude birth rate – live births per 1,000 population.

7. Extra-marital birth rate – rate of extra-marital births of total births as a per cent.
8. Total fertility rate – average number of children that would be born alive to a woman during her lifetime conforming to the age-specific fertility rates of a given year during her childbearing years.
9. Mean age of women at birth of first child.
10. Mean age of women at childbearing.

The data for analysis of these indicators has been chosen in ten points in time – in the years 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005. Missing values of indicators were EM-imputed.

## Factor analysis

We started with factor analysis . It transpired that the ten variables can be presented by three (non-correlated) factors, the total description rate is 85.5% (see Table 1). It concludes from here that family creation and reproduction behaviour is not a phenomena that can be described by one factor determining the trend, but a complex process determined by a number of latent variables. The rates of un-rotated factors are 48%, 26% and 12%, thus the first optimal factor describes less than half of the total deviation.

***Table 1. Factor Analysis of European population's demographic variables***

| ***Variable*** | Communality | Decisions making | Traditionality | Instability |
|---|---|---|---|---|
| Mean age of women at childbearing | 0.942 | 0.928 | 0.226 | -0.169 |
| Age of woman at first marriage | 0.906 | 0.890 | -0.285 | 0.182 |
| Woman's age at birth of first child | 0.839 | 0.881 | -0.251 | -0.018 |
| Crude birth rate | 0.890 | -0.012 | 0.902 | -0.275 |
| Total fertility rate | 0.832 | 0.030 | 0.880 | -0.238 |
| Crude marriage rate | 0.778 | -0.511 | 0.718 | -0.045 |
| Female total first marriage rate | 0.784 | -0.505 | 0.690 | -0.228 |
| Total divorce rate | 0.961 | 0.074 | -0.248 | 0.945 |
| Crude divorce rate | 0.934 | -0.190 | -0.141 | 0.939 |
| Extra-marital birth rate | 0.681 | 0.454 | -0.339 | 0.600 |
| Description % | 85.5 | 47.5 | 26.0 | 12.1 |

As a result of Factor Analysis three well interpretable factors were found.

1. ***Timing decisions factor*** describes 47,5% of the variables and is in strong positive correlation with the following variables:
   mean age of women at childbearing (0.93),
   age of woman at first marriage (0.89),
   age of women at birth of first child (0.88).

The positive direction of the *decision* factor corresponds to a situation where women take the family creation decisions relatively late.

2. ***Traditionality factor*** describes 26% of the variables observed and is in strong positive correlation with the following variables:
   crude birth rate (0.90),
   total period fertility rate (0.88),

crude marriage rate (0.72),
total first marriage rate of woman (0.69).

The positive direction of the *traditionality* factor corresponds to high marriage rate and high birth rate that forms the traditional family creation – giving birth pattern.

3. ***Family instability factor*** describes 12% of the variables and is in strong positive correlation with the following variables:
   total divorce rate (0.95),
   crude divorce rate (0.94),
   extra marital rate (0.60).

The positive direction of the *instability* factor corresponds to higher divorce rate.

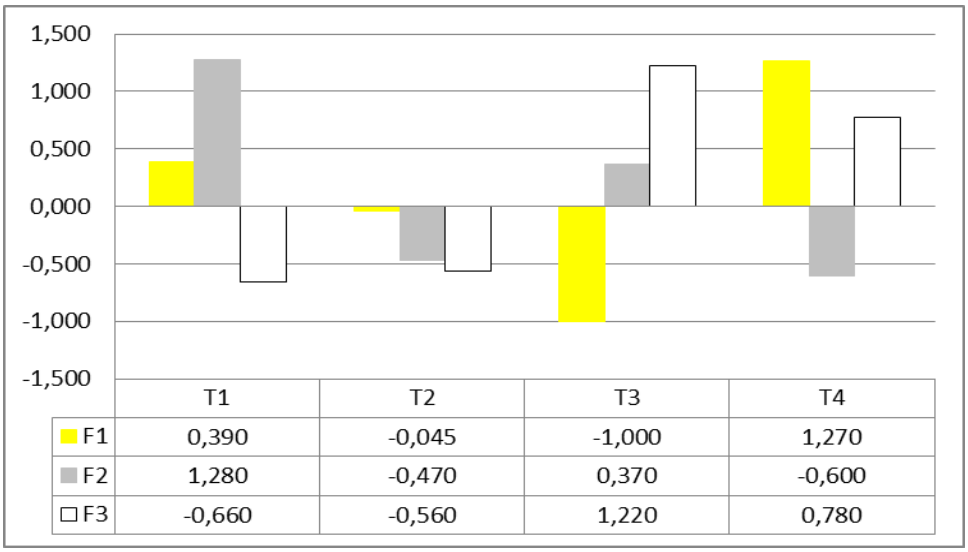
## Using Cluster Analysis to describe the hypothetical stages of SDT

Next we used the factors to discover the demographic behaviour patterns and types that characterize European countries in different time periods since 1960's. We used the K-means method and took the number of clusters equal to 4. As result the following groups were formed describing different types of demographic behaviour (Figure 1):

1) very high fertility, rather late decisions, rather stable family (T1),
2) rather early decisions, low fertility, quite stable family (T2),
3) very early family formation, quite high fertility, very unstable family (T3),
4) very late family formation, quite low fertility, very unstable family (T4).

*Our first hypothesis is that countries move in their demographic development from one type to another.*

The empirical data proved our hypothesis: there were totally 83 acts of type-changes during the 10-years period in 42 countries, i.e. in average 1,98 changes (see Table 6). There was only one country saving its position during the whole research period.




| | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| F1 | 0,390 | -0,045 | -1,000 | 1,270 |
| F2 | 1,280 | -0,470 | 0,370 | -0,600 |
| F3 | -0,660 | -0,560 | 1,220 | 0,780 |

Figure 1. Types of demographic behaviour in Europe 1960 – 2005.

*The second hypothesis is that there exists (at least partial) order of types in time. If so, we can regard these types as stages of SDT.*

The comparison of frequencies of types 1 and 4 in the first and the last time-period shows that in most cases (71%) the development started from type 1 in 60ies and finalised with type 4 in 2005 (again 71%, see Table 6). In no cases type 4 occurred earlier than 1980 and type 1 occurred only twice after 2000. Hence we can declare that the type 1 determines the initial stage (IS) of SDT and type 4 – the final stage (FS). As it follows, the types 2 and 3 are intermediate between the initial and final one and there are no statistically significant differences in the numbers of transitions 2→3 and 3→2 that are not among the most frequent ones at all. From here it follows that the types 2 and 3 together form the medium stage (MS) in the three-stage process of SDT. In fact, we have statistically proved that the SDT can be described in Europe as the sequence of transitions: IS (T1) → MS (T2, T3) → FS (T3).

## Influence of background factors on transition trace

Our following hypotheses are about the influence of historic-political and geographical dimensions of countries to the trace and timing of transitions between the SDT stages. To check these hypotheses, we divide European countries into groups by two factors.

***Historical-political groups:***

1. democratic market economy countries (D-countries, totally 20) and
2. countries that belonged to the socialist block from 1960 – 1991 and can be considered as "transition countries" from 1990 (S-countries, totally 22).

***Geographic groups*** (based on the latitudes of the capitals of the countries):

1. Northern European countries, lat>55 (8 countries),
1. Central European countries, lat 45…55 (18 countries),
2. Southern European countries, lat <45 (16 countries).

*The third hypothesis is: the medium stage of SDT depends on the historical-political background of countries.*

***Table 2. Frequencies of types 2 and 3 in S- and D-countries***

| | ***T2*** | ***T3*** | ***Total*** |
|---|---|---|---|
| ***D*** | ***77*** | ***6*** | ***83*** |
| ***S*** | ***99*** | ***61*** | ***160*** |
| ***Total*** | ***176*** | ***67*** | ***243*** |

The type 3, occurring significantly less frequently in D-countries compared with S-countries can be regarded as specific trace of S-countries that is not typical for SDT process in D-countries.

## Influence of background factors on timing of the transition

From the Table 3 it follows that the most intense period of transition IS→MS was in 1960—1970, but for transition MS→FS there were two more intense periods: 1975—1990 and 1995—2000.

***Table 5. Numbers of directed transitions in time***

| | 60/65 | 65/70 | 70/75 | 75/80 | 80/85 | 85/90 | 90/95 | 95/00 | 00/05 | Total | Reverse |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IS==>MS | 9 | 7 | 5 | 4 | 1 | 0 | 1 | 1 | 1 | 29 | 3 |
| MS==>FS | 0 | 0 | 0 | 4 | 6 | 4 | 2 | 8 | 5 | 29 | 0 |

*The fourth hypothesis: the timing of SDT depends on the historical-political background of countries.*

The Table 4 where the transition matrices (in the sense of Markov chains) have been calculated demonstrates that during the first period (1960—1990) more than half of the D-countries, but no S-countries reached the F-stage, while during the second period practically all remaining D countries and half of S-countries reach the F-stage.

***Table 4. Transition matrices (years 1960-1990 and 1995—2005)***

| 1960—1990 | End state | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Source state | S-countries | | | | D-countries | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| T1 | 0,675 | 0,225 | 0,10 | 0 | 0,605 | 0,369 | 0,026 | 0 |
| T2 | 0 | 0,90 | 0,10 | 0 | 0,03 | 0,80 | 0,05 | 0,12 |
| T3 | 0 | 0,10 | 0,90 | 0 | 0 | 0 | 0,33 | 0,67 |
| T4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1995—2005 | End state | | | | | | | |
| Source state | S-countries | | | | D-countries | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| T1 | 0 | 1,00 | 0 | 0 | 0,50 | 0 | 0 | 0,50 |
| T2 | 0,03 | 0,60 | 0,10 | 0,27 | 0 | 0,40 | 0 | 0,60 |
| T3 | 0 | 0,125 | 0,50 | 0,375 | | | | |
| T4 | 0 | 0 | 0 | 1,00 | 0 | 0 | 0 | 1,00 |

But also inside the S- and D-groups the timing of SDT varies significantly. From here follows:

*The fifth hypothesis: The timing of SDT in Europe depends on geographical situation (latitudes).*

*Table 5. Dependence of reaching FS of SDT from geographical factors*

| | *Reaching FS: beginning* | *Reaching FS: end* | *% of countries reached FS for the end of period* |
|---|---|---|---|
| | | ***D-countries*** | |
| ***North*** | ***1980*** | ***1990*** | ***100%*** |
| ***Central*** | ***1985*** | ***1995*** | ***100%*** |
| ***South*** | ***1995*** | ***2000*** | ***80%*** |
| | | ***S-countries*** | |
| ***North*** | ***2000*** | ***2005*** | ***100%*** |
| ***Central*** | ***2000*** | ***2005*** | ***55%*** |
| ***South*** | ***2000*** | ***2005*** | ***30%*** |

Table 5 shows that in both groups of countries there occurs the tendency that SDT starts in north and moves to south. Seemingly, the reasons are connected with cultural peculiarities of northern and southern European countries.

## Conclusion

We succeeded in proving almost all our hypotheses that means, the demographic development in Europe during the period 1960—1965 can be considered as SDT having three steps, where the trace is somewhat different in D (western) countries, where the transition took place earlier and was more straightforward and in S (eastern) countries, where the transition was delayed up to 2000$^{th}$ year and specific type of early family formation and highly unstable marriages occurred as medium stage of SDT.

*Table 6. Pattern of demographic behaviour*

| Country | 1960 | 1965 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| DK | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |
| FIN | 1 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 |
| S | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |
| IS | 1 | 1 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 |
| N | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 |
| B | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 |
| D | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 |
| IRL | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 |
| F | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 |
| L | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 |
| NL | 1 | 1 | 1 | 2 | 2 | 4 | 4 | 4 | 4 | 4 |
| A | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 |
| UK | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 |
| CH | 1 | 1 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 |
| GR | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 |
| E | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 4 | 4 | 4 |
| I | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 |
| CY | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 4 |
| M | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| P | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 4 | 4 |
| EST | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 |
| LAT | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 4 | 4 |
| LIT | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 4 |
| CR | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 4 | 4 |
| H | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 4 | 4 |
| PL | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 |
| R | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| SR | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 |
| BEL | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| MOL0 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| RF | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 |
| UKR | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| BG | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 |
| SLO | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 |
| CRO | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| MAC | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| AL | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| BOS | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| YUG | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| ARM | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 2 |
| AZ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| GEO | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 |

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