On Sensitivity in Population Forecasts

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The sensitivity of forecasts can be measured, for instance, either by calculating standard deviations, confidence intervals and other available error numbers or by determining useful alternative forecasts. The latter of these methods has been much used in population forecasts. In this case, for example, three alternative forecasts with different fertility assumptions (called medium, low and high) have been computed. The alternatives are, however, usually constructed in a very subjective manner. In typical statistical models, e.g. in the regression model, standard deviations and confidence intervals can be calculated for the forecasts. But in some instances, e.g. in the usual population forecasts, this method is not so simple. This report, which is based on Finnish population data, gives some test results on these questions. Regional results are also presented in these applications.

Model used

The author has built a model which will be used in experiments. This model has the following characteristics.

The model consists of three regions (or more, when needed), three educational levels, an adequate number of age groups, each of them by sex. The educational level, however, was omitted from our applications. The model has the following demographic components: immigration and emigration by regions, migration between regions, mortality and fertility by regions. The calculations for each of these factors are, of course, made by age groups. The model can be projected forward (and also backward). It is usually relevant to form the data so that the length of one step is one year. The model is more applicable if at each stage we can change demographic components and their relationships according to available groups. The changes are realized by so-called dynamizers, and they have equal influence on every age group in the components in question.

Data used

The sensitivity experiments were applied to the Finnish data. In these experiments, the structure of the population is more important than the country in question. The three regions that were formed were Region 1, Region 2 and Region 3. Region 1 consists of the four provinces of southern Finland. Their total population in 1979 was about 2 503 000 people. Region 1 is at the same time the most developed part of Finland. Region 2 consists of the six provinces of central Finland. Their population was 1 657 000 people in 1979. Region 3 consists of the two provinces of northern Finland. In 1979 only 612 000 people were living in this region. This is also the least developed of the three regions.

The basic data was formed from the years 1970—73. The population numbers and the transition shares by the regions, sex and age groups were calculated on the basis of this period. It was not easy to get exact data for the years after that. Therefore, more recent data had to be constructed: we projected our population to the year 1979 by using the dynamizers and the data on the behaviour of our demographic components. This tracking was successful: the differences were less than one per cent in the age groups and even less in the regional populations and in the whole population.

The most important sensitivity experiments were performed by starting from the tracked population of 1979. Some comparisons were also made with the basic population of 1970 and the projected population of 1990.

Approach

When estimating variation or error possibilities of the forecasts, it is appropriate to take advantage of the changes in the past development. We assume, in other words, that the changes in the future are similar to those in the past (assumption a).

The changes in the past can be determined in different ways. First, these changes are influenced by the periods of the past. Secondly, it is significant whether the changes are compared with the mean or the trend. The selections have a fairly sensitive influence on the size of the changes, but they are not of very great importance to the mutual ratios of the variables. In this context the rates of the changes were calculated in a simple manner: we used the standard deviations in relation to the mean and we selected the period 1963—77. Data for this period was available.

The relative standard deviations of the different variables have the following values:

migration from Region 2 to Region 1	.188
migration from Region 3 to Region 1	.253
migration from Region 1 to Region 2	.169
migration from Region 3 to Region 2	.120
migration from Region 1 to Region 3	.266
migration from Region 2 to Region 3	.134
emigration	.669
immigration	.753
mortality	.021
fertility	.131

The estimates for the changes of the forecasts were made with simulation experiments, by making the following additional assumptions:

Each of the ten basic variables has distributed normally with the above standard deviation and with the mean equal to that of the starting year (assumption b).

The basic variables are independent of each other. In other words, we will use different generators of random numbers with different variables (assumption c).

The changes take place immediately after the starting year, after which the transition coefficients remain constant (assumption d).

Our assumptions are, of course, simplified and not fully realistic. The assumption of independence, for example, is surely exaggerated, because, if migration is increasing from one region to another, it is increasing, in many cases, also between the other regions. This is in this research the reason why we did not separate immigration and emigration by region. The model would have allowed us to do that. Assumption d is also unrealistic because, for example, the change in fertility is in reality hardly more than 10 per cent during one year, which, however, is possible in our experiment. The assumption that the distribution of variables will be normal is also a bit uncertain but obviously correct, however. In short we can believe that our simplified assumptions will give results that are rather too large than too small.

Empirical results

The above series of experiments was realized in this case with 30 simulations. This number may seem small, and if we had more simulations, the results would be more precise. The most important results are given in table 1 and figures 1 and 2.

The results show us that the errors or deviations in forecasts will change over time. In age group 0 the error appears very rapidly but it hardly increases until after 10 years. The group aged 1—4 years behaves to an extent

quite similarly but the standard deviation increases more slowly and remains on a lower level than that of the previous age group. Correspondingly, in the group aged 5—19 years the standard deviation increases even more slowly. The next group — equaling the group of the active population — behaves, perhaps

Figure 1. Standard deviations of population forecasts during 20 years for the whole population and for some age groups of Finland, starting from 1979.

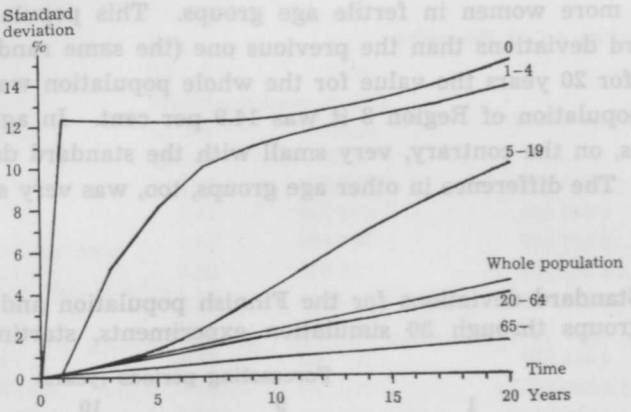
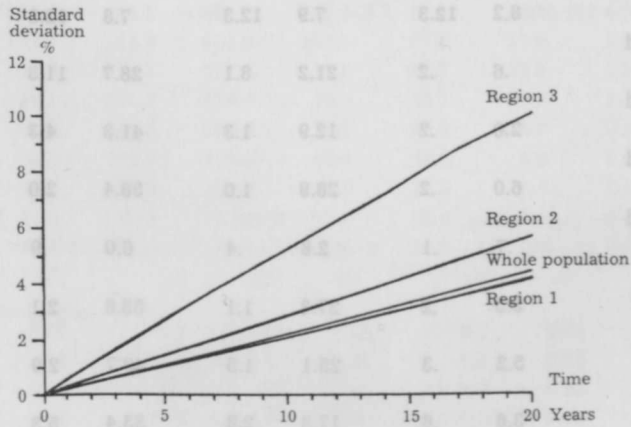


Figure 2. Standard deviations of population forecasts during 20 years for the whole population and for three regions of Finland, starting from 1979.



surprisingly, much the same way as the whole population. In the age group of the pensioners the errors are very small even during 20 years. Later on the deviation increases, of course, but longer periods, when adapted to practical situations, are not particularly useful.

On the contrary, the most developed and largest of the regions, Region 1, gets values very near to that of the whole population. The largest relative

errors occur in the least developed region, Region 3. The increase of the errors is very uniform.

Furthermore, the standard deviation for the number of deaths was calculated. For 15 years this remained nearly constant and after that it increased slowly.

The standard deviations depend of course on the population in question. In this context comparisons were made with two populations. The population of the year 1970 was, if compared with the population of 1979, clearly younger and included more women in fertile age groups. This population produced larger standard deviations than the previous one (the same random numbers): for example, for 20 years the value for the whole population was 6.3 per cent and for the population of Region 3 it was 14.9 per cent. In age group 0 the difference was, on the contrary, very small with the standard deviation being 15.4 per cent. The difference in other age groups, too, was very small with the

Table 1. Standard deviations for the Finnish population and its nine subgroups through 30 simulation experiments, starting from 1979.

Variable	Forecasting periods (years) 1		5		10		20	
	1000s	%	1000s	%	1000s	%	1000s	%
The whole population	10.8	.2	53.8	1.1	107.8	2.2	217.7	4.5
Population aged 0 year	8.2	12.3	7.9	12.3	7.8	12.5	8.7	15.2
Population aged 1—4 years	.6	.2	21.2	8.1	28.7	11.3	32.8	14.0
Population aged 5—19 years	2.0	.2	12.9	1.3	41.3	4.3	92.1	10.2
Population aged 20—64 years	6.0	.2	28.9	1.0	58.4	2.0	114.1	4.0
Population aged over 64 years	.7	.1	2.8	.4	6.0	.9	11.9	1.6
Population of Region 1	5.5	.2	27.8	1.1	53.8	2.1	106.1	4.3
Population of Region 2	5.2	.3	25.1	1.5	49.7	2.9	98.3	5.7
Population of Region 3	3.6	.6	17.3	2.8	33.4	5.3	63.9	10.1

exception of the age group 20—64 years, in which the standard deviation for 20 years was 6.6 per cent.

However, the population projected for the year 1990 produced very similar values as the population of the year 1979. This is natural because the younger age groups in these populations do not differ very much in size from

each other. For example the value for the whole population was 4.3 per cent and for Region 3 it was 9.5 per cent.

In conclusion, we can verify that standard deviations of the population forecasts are fairly large, especially if we also want to calculate the confidence intervals. The results may, in reality, be a bit smaller, because our assumptions might have increased the changes. The behaviour of the standard deviations over time is, however, reliable.