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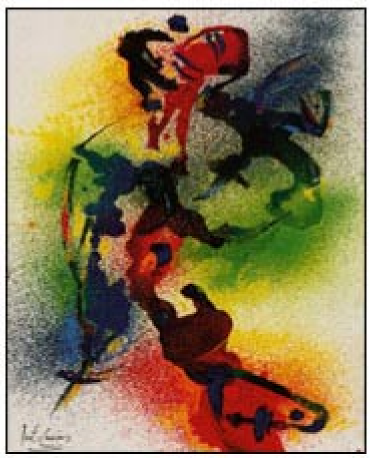

## *Different Statistical Measures Provide Different Perspectives on Digital Divide*

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# Different Statistical Measures Provide Different Perspectives on Digital Divide

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**Abstract**

A brief explanation of time distance methodology as a new view of time series data is provided. Existing static measures are left unchanged, complemented by proximity in time. The novel statistical measure S-distance measures the distance (proximity) in time between the points in time when the two series compared reach a specified level of the indicator X. It is a generic concept like static difference or growth rate.

In the empirical part its application to the gap between North America and Europe in Internet users per capita will serve as a vivid example of how different statistical measures lead to different conclusions, even about the direction of change in digital divide. A further application provides a time distance analysis of the indicator personal computers per capita for 27 countries over the period 1990-2001. Time distance results bring also new insights to the survey results. One of such examples will be the analysis of digital divide for selected disadvantaged categories for the EU 15 and selected countries derived form the chosen projects of the 5. Framework Programme.

Key words: comparisons, time distance, S-distance, digital divide, internet users and personal computer per capita, indicators, EU, inequality, convergence, cohesion

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# Different Statistical Measures Provide Different Perspectives on Digital Divide

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A brief explanation of time distance methodology as a new view of time series data is followed by its application to the gap between North America and Europe in Internet users per capita. It serves as a vivid example of how different statistical measures lead to different conclusions even about the direction of change in digital divide. A further application provides a time distance analysis of the indicator personal computers per capita for 27 countries over the period 1990-2001. Time distance results bring also new insights to the survey results about the digital divide for selected disadvantaged categories for the EU 15.

**Key words**: time distance, S-distance, digital divide, internet users and personal computer per capita, indicators, EU, inequality, convergence, cohesion

**JEL classifications:** C10, O30, O52, O57

## 1. Introduction and Methodology

The present state-of-the-art of comparative analysis lacks the imagination to extend beyond its current borders to encompass a new dimension that without any doubt exists in human perception when comparing different situations. Time is one of the most important reference frameworks in modern society. Yet the information about time embodied in the existing databases is not fully utilised for describing different situations and for analysing available data for the relevant patterns that can be derived from the understanding of different views of data. The novel time distance methodology offers an improvement at both conceptual and application levels.

This is not only a question of statistics and database analysis. It profoundly affects also the analytical and decision-making level by providing new insights for evaluation of policy and business alternatives. The understanding of the complexities of real life situation is not increased only by an increase of quantity and/or quality of empirical information. At least equally important are the concepts and tools of analysis that systematize and transform information into perceptions relevant for decision making and influencing human behavior. The perceptions formed and the decisions, behavior and actions undertaken are also influenced by the quantitative indicators and measures used in the semantics of discussing the issues, in setting the targets and in following their implementation. The better the analytical framework the greater the information content provided to experts, decision makers and general public.

The time distance approach as a new view of the information, using levels of the variable(s) as identifiers and time as the focus of comparison and numeraire, is theoretically universal, intuitively understandable and can be usefully applied as an important analytical and presentation tool to a wide variety of substantive fields. There are different ways of how the databases can be presented and analysed. Time has been in comparisons used mainly as location information, i.e. as a coordinate in a parameter frame forming a coordinate system that is used to organise (or index) a set of variables. In alternative words, it has played a role of a descriptor, subscript or identifier. The intention of this approach is to go further without replacing the existing views. If we choose to interchange the roles of the level of the indicator and time, a given level of the indicator becomes a descriptor or identifier: time becomes a numeraire in which certain distances between the compared units and indicators can be expressed and measured. While the whole approach and the broad range of possible applications are much more complex and general[1], the time distance is the priority choice because of its intuitive nature, and of the importance of the time dimension in the semantics of describing various situations in real life and forming our perceptions about them.

Time distance in general means the difference in time when two events occurred. We define a special category of time distance, which is related to the level of the analysed indicator. The suggested statistical measure S-distance[2] measures the distance (proximity) in time between the points in time when the two series compared reach a specified level of the indicator X. For a given level of $X_L$, $X_L = X_i(t_i) = X_j(t_j)$, and the S-distance (the time span separating unit (i) and unit (j) for the level $X_L$) will be written as[3]

$$S_{ij}(X_L) = \Delta T(X_L) = t_i(X_L) - t_j(X_L) \quad (1)$$

This is the first and most interesting result of the novel approach that rotates the database in such a way that it is recalculated for specified levels of the indicator X. With respect to time variable, from the usual time series ordering X=f(t) the inverse ordering is established $t=f(X_L)$. When we compare time series for a given indicator X for two units of comparison (i) and (j), a time matrix like Table 5 below is created.

As it will be shown below, the novel time distance approach provides interesting new insights to problems. On the theoretical level it is important to realise that in addition to the disparity (difference, distance) in the indicator space at a given point in time (e.g. between country (i) and country (j)), in principle there exist a theoretically equally universal disparity (difference, distance) in time when a certain level of the indicator is attained by the two compared units. From this idea of the multidimensional notion of disparity (proximity) it follows that the overall degree of disparity (proximity) is here conceived of as a weighted combination of the static and temporal dimensions of disparity.

From practically the same information (two vectors of values with time subscripts) an additional theoretically universal and practically relevant measure can be obtained that possesses also important practical benefits for empirical research and decision-making. First, since it is a new complementary view of the information by adding (n+1) dimension to existing measures, no previous results are replaced and our understanding can only be enriched by adding it to existing analysis. Second, being expressed in units of time, which everybody understands from ministers, managers to general public, it possesses one of the ideal characteristics of a presentation and communication instrument. It is expected that the analysis of and discussion about

[1] See Sicherl (1999) for discussion of the generic characteristics of time distance measure, parallel with static measure(s) of disparity and growth rate concepts, and extension to variables other than time.
[2] The observed distance in time (the number of years, quarters, months, days, minutes, etc.) is used as a temporal measure of disparity between the two series in the same way that the observed difference (absolute or relative) at a given point in time is used as a static measure of disparity.
[3] For elaboration see Sicherl (1999).

time distances will have considerable influence on how people form their perception about a situation and on public opinion.

## 2. Different Statistical Measures of the Gap between North America and Europe in Internet Users per Capita Show Diverse Conclusions[4]

The indicator Internet users per capita is an example of an indicator with a much higher rate of growth than that of GDP per capita. As time distance is a negative function of the growth rate of the indicator, it is expected that the time distance for some of the information society indicators with very high growth rates will be substantially smaller than that for GDP per capita. This is so despite the fact that static disparities for some of these indicators are larger than that of GDP per capita. In this section the illustrative example is done for the indicator Internet users per 1000 people by region. Data from Computer Industry Almanac Inc. include also projections for this indicator until the year 2005. Despite the great importance of the information society indicators in shaping the technological change and the economy, the accuracy of international comparisons for these indicators leaves much to be desired. Our focus in this paper is in the first instance methodological, showing that different statistical measures lead to different perceptions of the magnitude and the change in the gap between North America and Europe for Internet users per capita. Therefore we simply take the values and the geographical division from Computer Industry Almanac Inc. for granted.

**Table 1. Internet users per 1000 people by region**

| Time | North America | W. Europe/Scandinavia |
|---|---|---|
| 1995 | 104.9 | 22.1 |
| 1998 | 311.2 | 105.8 |
| 2000 | 492.6 | 220.5 |
| 2005 | 720.6 | 529.9 |

Source: Computer Industry Almanac Inc.
http://www.c-i-a.com/199908iu.htm

This data source shows that in 1998 the value for the indicator Internet users per capita was in North America (NAM) nearly three times higher than in Western Europe/Scandinavia (WES). This gap is in static terms much higher than that for GDP per capita. The time distance is roughly between 3 and 4 years, as shown in Table 3. Table 2 shows the average growth rates for NAM and WES for the three observed periods. For each of these periods the rate of growth for WES is higher than for NAM. If one were using only relative static measures of the gap the conclusion would be uncomplicated. Since the growth rate is higher for WES the conclusion would be that the gap is decreasing and that convergence is well under way.

[4] This section is based on Sicherl (2000). While the data and projections by the Computer Industry Almanac Inc. should not be considered as official estimates of the position in the two regions, these figures are used here as a convenient example of how different statistical measures produce different conclusions even as far as the direction of change of the disparities between the compared regions is concerned.

**Table 2. Average percentage rate of increase per year**

| Period | North America | W. Europe/Scandinavia |
|---|---|---|
| 1998/1995 | 44 | 69 |
| 2000/1998 | 26 | 44 |
| 2005/2000 | 8 | 19 |

The broader conceptual and statistical framework suggested here looks at the situation from more perspectives. Table 3 shows the numerical results for three views of the gap between NAM and WES, while Table 4 draws the main conclusions for the five statistical measures used in the discussion of the existing and projected gaps for the Internet users per capita. In this case all the three measures of the gap (absolute difference, percentage difference and S-distance) show three different conclusions about the directions of the change of the gap between NAM and WES for the period 1998-2005.

Absolute difference is constant, at both compared points in time about 200 more people per 1000 people are Internet users in NAM as compared to WES. Percentage difference is decreasing substantially, in 2005 it is projected that the value of the indicator in NAM will be only 36 per cent higher than in WES. This degree of relative disparity would in 2005 be already lower than the disparity in GDP per capita in 1999. However, time distance would be increasing, in 1998 the time lead of NAM for Internet users per capita was according to this set of data 3 years, while for 2005 the projected time lead will be 4.2 years.

**Table 3. Three measures of differences in Internet users per 1000 people between North America and W. Europe/Scandinavia**

| Time | Absolute difference | Percentage difference | Time distance in years |
|---|---|---|---|
| 1995 | 83 | 375 | |
| 1998 | 205 | 194 | -3.0 |
| 2000 | 272 | 123 | -3.3 |
| 2005 | 191 | 36 | -4.2 |

This is a surprising and counterintuitive conclusion that can be systematically obtained and explained only within the broader conceptual framework. The fact that growth rates for the same period are higher in Europe than in North America does not tell the whole story. When compared for given levels, at least until the projected level of 500 per 1000 people, the diffusion of Internet is shown to be always faster in North America than in Europe. Such a conclusion is simply absent from the conventional measures. A country or a company that reduces the static percentage disparity by growing faster than its benchmark may erroneously believe that it is sufficiently improving its competitive position[5]. However, in the present rapid changes in the

[5] The *e*Europe targets should also be checked and made explicit with the use of this broader framework.

economy it may be for a company much more important not to increase the lag in time behind its competition. Such a broader analysis could be useful also for market analysis of penetration rates for numerous products.

**Table 4. Internet users per capita: comparing different views of the gap between North America and W. Europe/Scandinavia**

| | | | |
|---|---|---|---|
| Measure 1 | Level of the indicator | *HIGHER IN NORTH AMERICA* | NAM > WES |
| Measure 2 | Growth rate per year | *HIGHER IN W.EUROPE/SCANDINAVIA* | NAM < WES |
| Measure 3 | GAP: Absolute difference | *CONSTANT* | = |
| Measure 4 | GAP: Relative difference | *DECREASING* | ↓ |
| Measure 5 | GAP: Time distance | *INCREASING* | ↑ |

Table 4 illustrates for this example in a more general format that the five measures analysed show very different results describing the same situation. The level of the indicator is higher in NAM than in WES, the rate of growth is higher in WES than in NAM; absolute difference of the gap between NAM and WES is constant, relative difference is decreasing and time distance is increasing. First, all of the perspectives have to be studied simultaneously for a better perception of the reality. Second, what in the present state-of-art of comparative analysis seems to be a paradox (that relative difference is decreasing and that time distance is at the same time increasing) can easily be resolved in the broader theoretical and analytical framework applied here.

## 3. Resolving the Paradox: Two Time Measures for Comparing Internet Users per Capita by Specified Penetration Levels (Internet Users per 1000 People)

As explained in Section 1 and in more detail in the introductory article of the Journal, the theoretical underpinning of S-distance as a novel generic statistical measure is based on the idea to use levels of the variables as identifiers and time as the focus of comparison and numeraire. This means that the roles of time and indicator values in database are reversed. Generally, the first result of the application of this approach is a time matrix specifying the time(s) when a specified level of the indicator was achieved in each compared unit. For our numerical example, the time matrix is presented in Table 5.

**Table 5. Time matrix: time when a specified level of the indicator was achieved in each compared unit and the corresponding S-distance between NAM and WES**

| Level | Time NAM | Time WES | S-distance in years |
|---|---|---|---|
| 100 | | 1997.79 | |
| 200 | 1996.38 | 1999.64 | -3.26 |
| 300 | 1997.84 | 2001.28 | -3.44 |
| 400 | 1998.98 | 2002.9 | -3.92 |
| 500 | 2000.16 | 2004.52 | -4.36 |
| 600 | 2002.36 | | |
| 700 | 2004.55 | | |

The last column in Table 5 is the earlier discussed S-distance between NAM and WES for a specified penetration level (Internet users per 1000 people). It is calculated as the horizontal difference between the established times in the time matrix when a given penetration level was attained in the compared units. However, the time matrix can be further utilised in its vertical direction. This means that for each unit separately one can measure the time needed to pass from the lower to the higher penetration rate specified in the time matrix. Let us call this second time distance measure S-step. It is attained by subtracting vertically the consecutive times in the respective columns of the time matrix. In Table 6 the numerical values of the time needed to pass from one to the next specified higher level of presentation are presented for the analysed case.

**Table 6. S-step: time needed to pass from one to the next specified higher level of penetration**

| Level change | S-step in years between successive levels of penetration | |
|---|---|---|
| | NAM | WES |
| 200, 100 | | 1.85 |
| 300, 200 | 1.46 | 1.64 |
| 400, 300 | 1.14 | 1.62 |
| 500, 400 | 1.18 | 1.62 |
| 600, 500 | 2.2 | |
| 700, 600 | 2.19 | |

By utilising the information in the time matrix both in the horizontal and in the vertical direction and thus attaining two different time measures, the puzzle from the previous section is solved. In Table 6 one can see that for each increase between the same specified levels of the indicator NAM needed less time than WES. As this was true for all steps in the past, it is understandable that S-distance between NAM and WES for the same level of the indicator was increasing in the observed period. In other words, as penetration rates for many indicators follow a logistic curve, compared for the same sections of the logistic curve Internet users per capita would grow faster in NAM under the specified projection by Computer Industry Almanac Inc.

## 4. Personal computers per 100 inhabitants[6]

In this section the earlier application of time distance analysis of Internet users per capita for the two world regions is supplemented with the time distance analysis of the indicator personal computers per 100 inhabitants for the case of EU15 countries and the ten accessing countries, as well as for the USA and Japan. Here, the benchmark is the position of Slovenia, against which the leads and lags of other countries are calculated. The position of Slovenia with respect to the availability of personal computers is very close to the EU15 average for the last five years. First we can look at the position of Slovenia in terms of one of the most frequently used static measures of disparity, i.e. when the position is expressed as an index where the level of EU15 average in the given year is 100. Table 7 presents the absolute levels of the indicator, and Table 8 the indexes with EU15=100. This is a standard form of presentation and can lead to some conclusions. First, the position of Slovenia improved considerably from the index of 46 in 1993 to 101 in 1999, when it surpassed the EU15 average level and then dropped again to 89 in 2001. Second, in 2001 the position of Slovenia is the best among the analysed ten candidate countries. It is also better than in Portugal, Italy, Spain and Greece. Third, being close to EU15 average does not mean the proper benchmarking with the best. Thus the value of the personal computers per 100 inhabitants is in the USA twice the value for the EU15 average. Also within EU Scandinavian countries and Netherlands are clearly more advanced.

Graph 1 presents the time distances between Slovenia and the analysed countries in 2001. On the left side of the graph the negative values of the S-distance show how many years earlier the present value of the indicator for Slovenia was reached in the compared countries. For instance, the time lead of about four years means that the value of 27.6 for Slovenia in 2001 was achieved in Netherlands in 1997. Similarly, on the right hand side of the graph S-distances indicating time lag behind Slovenia show how many years earlier Slovenia achieved the value of the indicator for these countries in 2001. As shown, such information already existed in the existing database (Table 7), but was not until now utilized at all because the present state-of-the-art is unnecessarily overemphasizing the static aspects of disparities and gap analysis.

Table 9 shows the estimates of time distances for more years of the analysed period, expressed in years, Slovenia being the chosen base. The countries are here sorted by the degree of deviation in time from Slovenia. The greatest lead is that of the USA, which in 2001 amounted to nearly 8 years. This also means that the EU15 average is lagging the USA for personal computers per capita for at least 6 years. S-distance estimates are graphed in Graph 2, which visually underlines the results in Table 9. For all the countries lagging Slovenia the time lag has increased over time, only Portugal has somewhat decreased the time lag behind Slovenia. With respect to more advanced countries in terms of density of personal computers, they have been increasing the lead in time. The position of Slovenia was in this respect best in 1997 when the time lead of most advanced EU countries was between 2-3 years, which now increased to about 5-6 years against the best performers in the EU.

[6] This section is based on Sicherl (2002), which was financed by the Ministry of Information Society in Slovenia. The Slovenian text can be found on http://www2.gov.si/mid/mid.nsf under Indikatorji.

Obviously Slovenia was a fast adopter of the personal computers in the early phases of that development, but did not sustain the further speed of adoption as far as the best performers are concerned. Compared with EU15 average, there is a slightly different situation. Until 1999 Slovenia had slightly increased its relative position, so that in 1999 the indicator personal computers per 100 inhabitants was slightly higher than for the EU15 average. Between 1999 and 2001 the trend reversed. Such analysis can be presented also in two dimensions simultaneously in the same graph, as it is done in Graph 3. This time for static measure of disparity the percentage difference from the Slovenian value is chosen as the representative of static measures of disparity. In such a way also differences with other countries can be displayed or two-dimensional position for a number of indicators in a graph. When needed, such two-dimensional presentations can be very useful to underline to policy makers and stakeholders that the situation may look quite different if evaluated both by static measure(s) and time distance simultaneously. This can provide an especially sharp contrast when the comparison is done across several indicators with very different growth rates.

Table 10 shows another useful way of the application of the generic idea that databases can be analysed also by levels of the indicator as the focus of attention on which the time distance methodology is based. For personal computers per 100 inhabitants levels in steps of 5% were arbitrarily selected and by the interpolation of data in Table 7 the respective times were calculated. The advantage of such a time matrix table is its graphical quality of presentation, providing a number of observations to a searching mind. It has table-graph combination qualities. It is sometimes very difficult to observe details in a trend graph when you have 28 units in the graph. Not all possible comparisons from such a table-graph will be mentioned here, but only a few. First, one immediately sees which levels were reached by the analysed countries. Second, one also grasps over how many level classes they have advanced in the time span of the period of the analysis. Third, for a given level of the indicator one could read off the S-distance value for that level: e.g. for the level of 40% Sweden was in January 1999 one year and three months behind the USA and two years ahead of Denmark, etc. but the time distance with EU15 at that level cannot be determined since EU15 average has not reached that level yet.

**Table 7. Personal computers per 100 inhabitants**

| Time | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EU15 | 7 | 8.1 | 9.7 | 10.9 | 12.4 | 14.3 | 16.7 | 19.4 | 22.4 | 25 | 28.2 | 31 |
| BE | 9 | 10 | 12 | 13.9 | 15.8 | 17.8 | 21.7 | 24.6 | 28.5 | 31.3 | 34.2 | 36.1 |
| DK | 11.7 | 13.4 | 15.5 | 18 | 19.2 | 27.1 | 30.5 | 36 | 37.8 | 41.4 | 43.2 | 44.9 |
| DE | 8.2 | 9.4 | 11 | 12.6 | 15.1 | 17.9 | 20.9 | 23.9 | 27.9 | 29.7 | 33.6 | 35.3 |
| GR | 1.7 | 2 | 2.2 | 2.6 | 2.9 | 3.4 | 3.5 | 4.5 | 5.2 | 5.7 | 7.6 | 8.5 |
| ES | 2.8 | 3.3 | 3.8 | 4.4 | 4.9 | 6.1 | 7.9 | 9.7 | 10.9 | 12.1 | 14.6 | 16.9 |
| FR | 7.1 | 7.4 | 10.9 | 11.7 | 13.5 | 14.7 | 16.2 | 19.4 | 23.3 | 26.8 | 30.5 | 33.9 |
| IE | 8.6 | 10.2 | 11.6 | 13.4 | 15.6 | 18.3 | 21 | 24.1 | 27.3 | 31.6 | 36 | 39.2 |
| IT | 3.7 | 4.6 | 5.5 | 6.1 | 7.2 | 8.4 | 9.2 | 11.3 | 13.2 | 15.6 | 17.9 | 19.5 |
| LU | 26.4 | 28.6 | 30.8 | 32.9 | 34.9 | 36.9 | 37.5 | 38.3 | 38.9 | 39.6 | 45.9 | 45.3 |
| NL | 9.4 | 11.3 | 13.2 | 14.4 | 16.9 | 20.1 | 23.2 | 28.3 | 32.6 | 36.2 | 39.7 | 43.2 |
| AT | 6.5 | 7.7 | 8.9 | 10 | 11.2 | 16.2 | 17.4 | 21.1 | 23.5 | 26 | 28 | 29.6 |
| PT | 2.6 | 3 | 3.5 | 4 | 4.3 | 5.5 | 6.7 | 7.3 | 8 | 8.2 | 11.9 | 22.4 |
| FI | 10.1 | 11.4 | 12.9 | 14.2 | 16 | 23.5 | 27.4 | 31.2 | 35 | 36 | 39.6 | 42.5 |
| SE | 10.6 | 12.8 | 13.9 | 15 | 18.3 | 7.1 | 29.4 | 33.9 | 39.6 | 45.2 | 50.8 | 56.3 |
| UK | 10.8 | 12.5 | 14.5 | 16.5 | 17 | 20.2 | 21.6 | 23.9 | 26.9 | 30.3 | 33.9 | 36.8 |
| CY | 0.7 | 1.5 | 2.1 | 2.8 | 3.5 | 4.8 | 6.8 | 10.1 | 12.1 | 17.3 | 19.9 | 22.4 |
| CZ | 1.2 | 1.4 | 2.4 | 2.9 | 4.4 | 5.3 | 6.8 | 8.2 | 9.7 | 10.7 | 12.2 | 13.6 |
| EE | 1.9 | 2.2 | 2.6 | 3.3 | 4 | 4.7 | 6.8 | 9.6 | 11.3 | 13.5 | 16 | 18.3 |
| HU | 1 | 1.2 | 1.9 | 2.7 | 3.4 | 3.9 | 4.4 | 5.8 | 6.5 | 7.4 | 8.7 | 10 |
| LT | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 2.7 | 3.4 | 5.4 | 5.9 | 6.5 | 7 |
| LV | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.8 | 2 | 4 | 6.1 | 8.2 | 14.3 | 15.2 |
| MT | 1.4 | 2.8 | 4.2 | 5.5 | 6.8 | 8.1 | 10.8 | 13.4 | 15.9 | 18.5 | 21 | 23 |
| PL | 0.8 | 1 | 1.3 | 1.8 | 2.2 | 2.9 | 3.1 | 3.9 | 4.9 | 6.2 | 6.9 | 8.5 |
| SI | | | | 5 | 7.5 | 10.1 | 12.6 | 18.9 | 21.2 | 25.3 | 27.6 | 27.6 |
| SK | 0.8 | 0.9 | 1.5 | 1.9 | 2.8 | 4.1 | 4.7 | 7 | 8.7 | 10.9 | 13.7 | 14.8 |
| US | 21.8 | 23.5 | 25.4 | 27.4 | 29.9 | 33 | 36.6 | 40.9 | 46.1 | 51.9 | 58.5 | 62.3 |
| JP | 6 | 6.5 | 6.9 | 7.8 | 9.2 | 12 | 16.3 | 20.5 | 23.8 | 28.7 | 31.5 | 34.9 |

Source: Eurostat, New Chronos, Theme 4, Industry, Trade and Services, Information Society Statistics, MISC, accessed October 14, 2002

**Table 8. Index as a measure of static disparities for personal computers per 100 inhabitants (EU15=100)**

| Time | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EU15 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| BE | 129 | 123 | 124 | 128 | 127 | 124 | 130 | 127 | 127 | 125 | 121 | 116 |
| DK | 167 | 165 | 160 | 165 | 155 | 190 | 183 | 186 | 169 | 166 | 153 | 145 |
| DE | 117 | 116 | 113 | 116 | 122 | 125 | 125 | 123 | 125 | 119 | 119 | 114 |
| GR | 24 | 25 | 23 | 24 | 23 | 24 | 21 | 23 | 23 | 23 | 27 | 27 |
| ES | 40 | 41 | 39 | 40 | 40 | 43 | 47 | 50 | 49 | 48 | 52 | 55 |
| FR | 101 | 91 | 112 | 107 | 109 | 103 | 97 | 100 | 104 | 107 | 108 | 109 |
| IE | 123 | 126 | 120 | 123 | 126 | 128 | 126 | 124 | 122 | 126 | 128 | 126 |
| IT | 53 | 57 | 57 | 56 | 58 | 59 | 55 | 58 | 59 | 62 | 63 | 63 |
| LU | 377 | 353 | 318 | 302 | 281 | 258 | 225 | 197 | 174 | 158 | 163 | 146 |
| NL | 134 | 140 | 136 | 132 | 136 | 141 | 139 | 146 | 146 | 145 | 141 | 139 |
| AT | 93 | 95 | 92 | 92 | 90 | 113 | 104 | 109 | 105 | 104 | 99 | 95 |
| PT | 37 | 37 | 36 | 37 | 35 | 38 | 40 | 38 | 36 | 33 | 42 | 72 |
| FI | 144 | 141 | 133 | 130 | 129 | 164 | 164 | 161 | 156 | 144 | 140 | 137 |
| SE | 151 | 158 | 143 | 138 | 148 | 50 | 176 | 175 | 177 | 181 | 180 | 182 |
| UK | 154 | 154 | 149 | 151 | 137 | 141 | 129 | 123 | 120 | 121 | 120 | 119 |
| CY | 10 | 19 | 22 | 26 | 28 | 34 | 41 | 52 | 54 | 69 | 71 | 72 |
| CZ | 17 | 17 | 25 | 27 | 35 | 37 | 41 | 42 | 43 | 43 | 43 | 44 |
| EE | 27 | 27 | 27 | 30 | 32 | 33 | 41 | 49 | 50 | 54 | 57 | 59 |
| HU | 14 | 15 | 20 | 25 | 27 | 27 | 26 | 30 | 29 | 30 | 31 | 32 |
| LT | 3 | 2 | 3 | 4 | 4 | 4 | 16 | 18 | 24 | 24 | 23 | 23 |
| LV | 1 | 1 | 2 | 2 | 2 | 6 | 12 | 21 | 27 | 33 | 51 | 49 |
| MT | 20 | 35 | 43 | 50 | 55 | 57 | 65 | 69 | 71 | 74 | 74 | 74 |
| PL | 11 | 12 | 13 | 17 | 18 | 20 | 19 | 20 | 22 | 25 | 24 | 27 |
| SI | | | | 46 | 60 | 71 | 75 | 97 | 95 | 101 | 98 | 89 |
| SK | 11 | 11 | 15 | 17 | 23 | 29 | 28 | 36 | 39 | 44 | 49 | 48 |
| US | 311 | 290 | 262 | 251 | 241 | 231 | 219 | 211 | 206 | 208 | 207 | 201 |
| JP | 86 | 80 | 71 | 72 | 74 | 84 | 98 | 106 | 106 | 115 | 112 | 113 |

Source: Table 7.

**Figure 1. Time distance between Slovenia and selected countries for personal computers per 100 inhabitants 2001**

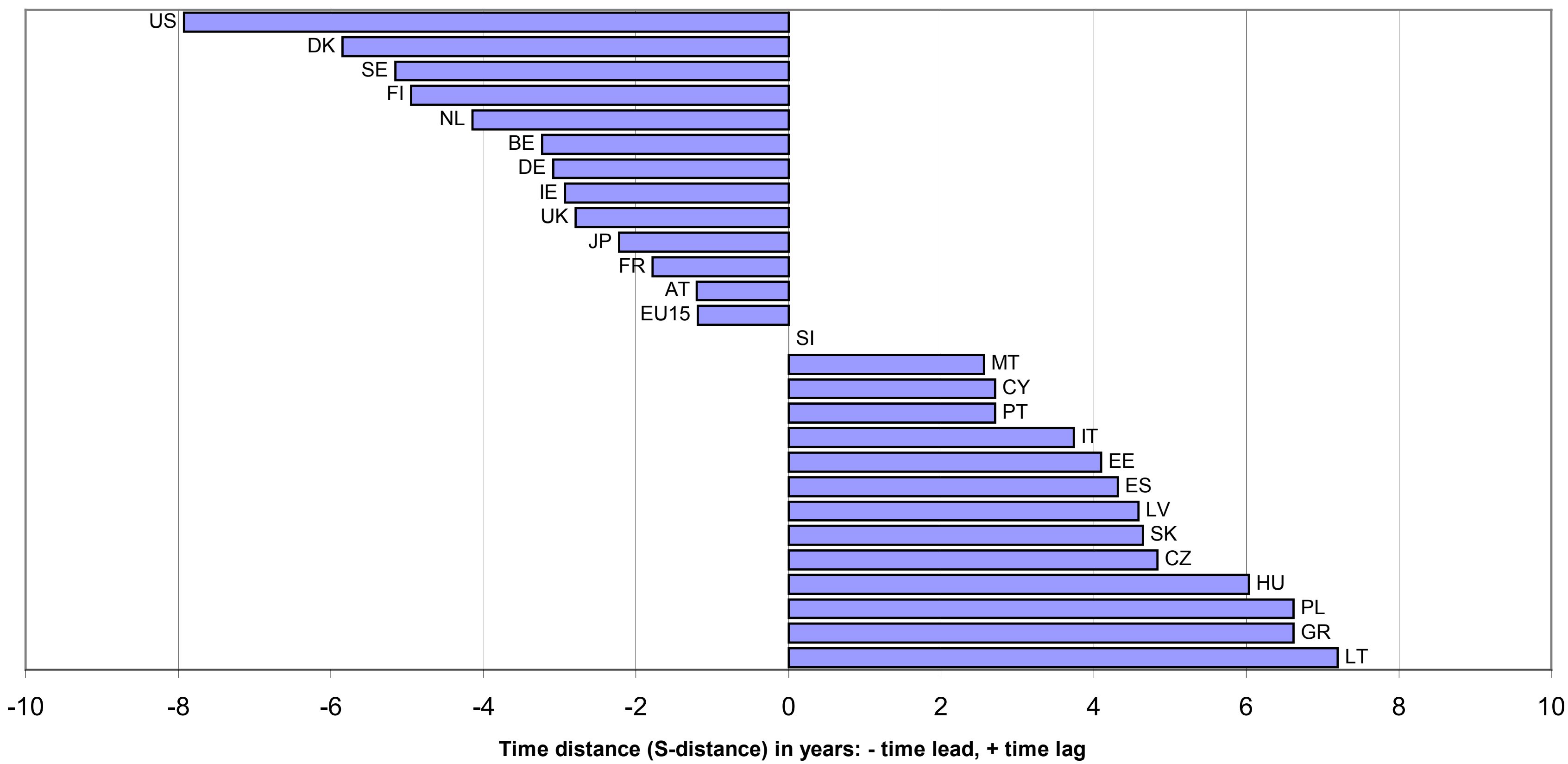

**Table 9. Estimates of time distances for personal computers per 100 inhabitants over the period**

| *Time* | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|
| *US* | | | | | | -6.9 | -7.9 |
| *DK* | | | -3.3 | -3.8 | -4.2 | -4.9 | -5.9 |
| *SE* | | | -1.9 | -2.7 | -3.3 | -4.2 | -5.2 |
| *FI* | | | -2.6 | -3.3 | -3.5 | -4.0 | -5.0 |
| *NL* | | | -2.4 | -2.7 | -2.6 | -3.1 | -4.1 |
| *BE* | | | -1.7 | -2.1 | -1.8 | -2.2 | -3.2 |
| *DE* | | -3.0 | -1.7 | -1.9 | -1.7 | -2.1 | -3.1 |
| *IE* | | | -1.8 | -1.9 | -1.6 | -1.9 | -2.9 |
| *UK* | | | -2.4 | -2.3 | -1.5 | -1.8 | -2.8 |
| *JP* | -0.7 | -0.9 | -0.4 | -0.8 | -0.7 | -1.2 | -2.2 |
| *FR* | | -2.5 | -0.2 | -0.5 | -0.4 | -0.8 | -1.8 |
| *AT* | -1.9 | -1.7 | -0.6 | -1.0 | -0.3 | -0.2 | -1.2 |
| *EU15* | | **-1.9** | **-0.2** | **-0.4** | **0.1** | **-0.2** | **-1.2** |
| *SI* | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| *MT* | 0.8 | 0.7 | 0.9 | 1.5 | 2.1 | 2.1 | 2.6 |
| *PT* | 1.8 | 2.3 | 3.1 | 3.8 | 4.7 | 4.3 | 2.7 |
| *CY* | | 2.3 | 2.0 | 2.2 | 2.3 | 2.6 | 2.7 |
| *IT* | 0.7 | 1.4 | 1.5 | 1.9 | 2.5 | 3.2 | 3.7 |
| *EE* | | 2.3 | 2.2 | 2.5 | 2.9 | 3.5 | 4.1 |
| *ES* | 1.6 | 1.9 | 2.2 | 2.7 | 3.2 | 3.7 | 4.3 |
| *LV* | | | | 4.6 | 4.7 | 3.7 | 4.6 |
| *SK* | | | 3.2 | 3.5 | 3.7 | 3.8 | 4.7 |
| *CZ* | 1.9 | 2.3 | 2.7 | 3.2 | 3.8 | 4.2 | 4.8 |
| *HU* | | | 3.7 | 4.4 | 5.0 | 5.5 | 6.0 |
| *GR* | | | | 4.9 | 5.7 | 6.0 | 6.6 |
| *PL* | | | | | 5.5 | 6.2 | 6.6 |
| *LT* | | | | 4.8 | 5.6 | 6.4 | 7.2 |

Source: own calculations based on data in Table 7.

**Figure 2. Time distances between Slovenia and selected countries for personal computers per 100 inhabitants for the period 1995-2001**

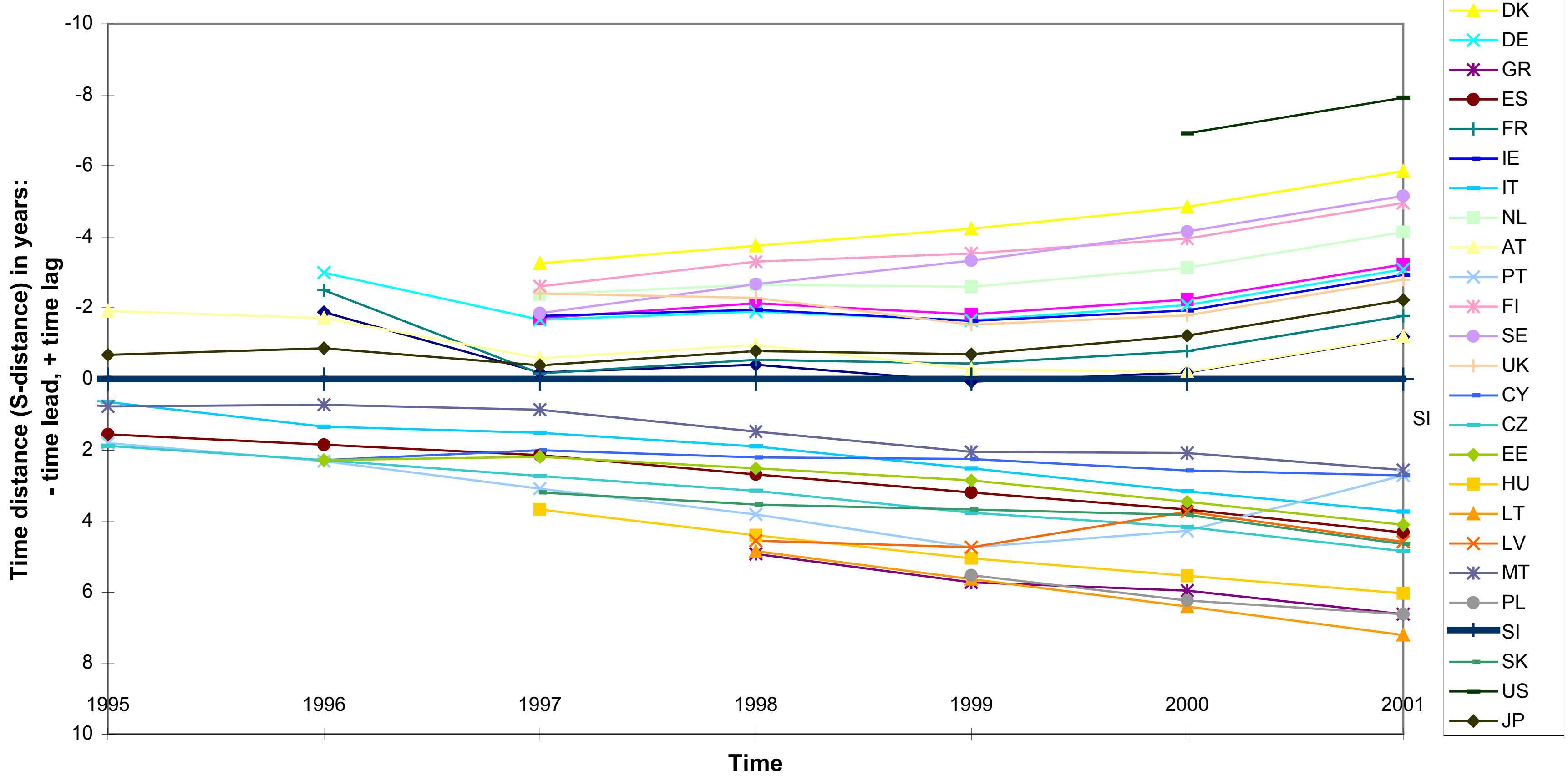

**Figure 3. Gap analyses in two dimensions for personal comptuters per 1000 inhabitants: static percentage difference and time distance for EU15 from Slovenia**

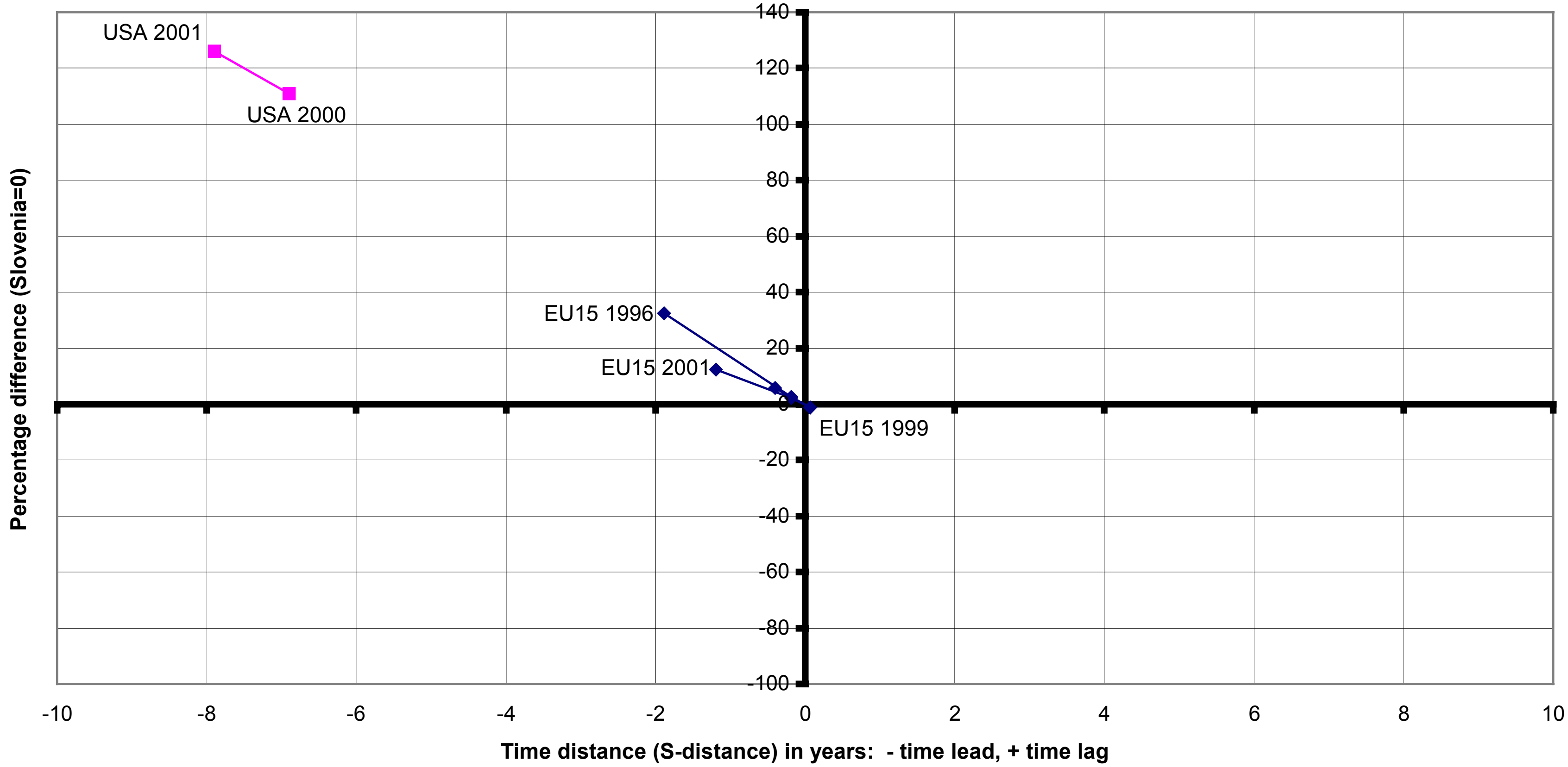

**Table 10. Time when a certain level of the indicator was attained in each country**

| *Level(%)* | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| *EU15* | | | Apr-96 | Mar-98 | Dec-99 | Aug-01 | | | | | | |
| *BE* | | | Jul-94 | Jul-96 | Feb-98 | Jul-99 | Jun-01 | | | | | |
| *DK* | | | | Feb-95 | Sep-95 | Nov-96 | Oct-97 | Aug-99 | | | | |
| *DE* | | | Dec-94 | Sep-96 | Apr-98 | Jan-00 | Oct-01 | | | | | |
| *GR* | Sep-98 | | | | | | | | | | | |
| *ES* | Jan-95 | Apr-98 | Mar-01 | | | | | | | | | |
| *FR* | | | Mar-96 | Feb-98 | Jun-99 | Nov-00 | | | | | | |
| *IE* | | | Sep-94 | Aug-96 | Apr-98 | Aug-99 | Oct-00 | | | | | |
| *IT* | | May-97 | Sep-99 | | | | | | | | | |
| *LU* | | | | | | | Jan-95 | Jan-00 | Nov-00 | | | |
| *NL* | | | Mar-94 | Dec-95 | May-97 | May-98 | Aug-99 | Jan-01 | | | | |
| *AT* | | Dec-93 | Oct-95 | Sep-97 | Aug-99 | | | | | | | |
| *PT* | Jul-95 | Jun-00 | Apr-01 | Oct-01 | | | | | | | | |
| *FI* | | | Jun-94 | Jul-95 | May-96 | Sep-97 | Dec-98 | Feb-01 | | | | |
| *SE* | | | Dec-93 | Mar-96 | Aug-96 | Feb-97 | Mar-98 | Jan-99 | Dec-99 | Nov-00 | Oct-01 | |
| *UK* | | | | Dec-95 | May-98 | Nov-99 | May-01 | | | | | |
| *CY* | Feb-96 | Dec-97 | Jul-99 | Jan-01 | | | | | | | | |
| *CZ* | Aug-95 | Apr-99 | | | | | | | | | | |
| *EE* | Feb-96 | Mar-98 | Aug-00 | | | | | | | | | |
| *HU* | Jun-97 | Dec-01 | | | | | | | | | | |
| *LT* | Oct-98 | | | | | | | | | | | |
| *LV* | Jun-98 | Apr-00 | Oct-01 | | | | | | | | | |
| *MT* | | Sep-96 | Aug-98 | Aug-00 | | | | | | | | |
| *PL* | Jan-99 | | | | | | | | | | | |
| *SI* | Dec-93 | Dec-95 | May-97 | Jun-98 | Dec-99 | | | | | | | |
| *SK* | Feb-97 | Aug-99 | | | | | | | | | | |
| *US* | | | | | | Jan-95 | Jul-96 | Oct-97 | Oct-98 | Sep-99 | Jun-00 | May-01 |
| *JP* | | Apr-95 | Sep-96 | Nov-97 | Mar-99 | Jun-00 | | | | | | |

Source: own calculations based on data in Table 7.

## 5. Time Distance Analysis Applied to Survey Results on Digital Divide

Time distance methodology can also be usefully applied as an additional presentation tool in analysis of surveys. The main problem here is that detailed surveys are usually available for a given point in time and that it is not easy to find a series of surveys that are comparable over a longer period of time. The example used in this section is based on the data from the SIBIS project (Statistical Indicators Benchmarking the Information Society, IST-2000-26276), which is funded by the European Community under the "Information Society Technology" Programme (1998-2002). I wish to thank Werner Korte, Karsten Gareis, Hannes Selhofer and Tobias Huesing for providing me with the data for the selected categories from three surveys: Eurobarometer Jan-Feb 1997, Eurobarometer Oct-Nov 2000, and SIBIS 2002[7].

**The first example is a comparison for the indicator total computer usage (penetration rate) across the selected countries.** The bar graph of time distances from the EU15 average (Figure 4) is easy to understand, comments are needed only for the extreme values on both sides. Since time series are not long enough, there are no intersections with EU15 average levels for the best and the worst performers. The time span between the first and the last survey is 63 months, which means that the three early adopters had reached the present EU15 average level **earlier** than 63 months ago, and also that the two late adopters present level had been attained by the present EU15 average level **earlier** than 63 months ago (i.e. that their lag is more than 63 months). Though we do not have a point estimate (if one does not wish to make extrapolations that are possible) this is still good information adding to the analysis of static measures.

It can be claimed that Table 11. 'Time for a given level of the indicator' is very useful for the presentation of time distance (and other) insight that this approach can add. Using interpolation, it can be estimated from the input data at what point in time a certain level of the indicator was attained by each unit (country). This time matrix is then the base for further calculations of S-distance and S-step, which are explained in Section 3. However, the calculation of S-step measure is not further elaborated in this example.As discussed earlier, such a table has an important visualisation quality for presentation, providing a number of observations in a single table with table-graph combination qualities. First, one immediately sees which level of computer usage the EU15 countries reached in the analysed period. Second, one can also grasp over how many level classes of computer usage these countries advanced in the time span of the period of the analysis. Third, for a given level of the indicator one could read off the S-distance value for that level: e.g. for the level of penetration rate 50% Germany was in July 2001 two months ahead of EU15 and five months ahead of Belgium etc., but the time distance with Denmark, Sweden or the Netherlands cannot be determined since all of them were at higher levels throughout the period of the analysis. Fourth, S-step can be derived, but this is not used here.

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[7] The detailed description of the definition of the disadvantaged groups is found in Selhofer and Huesing (2002). They also provide a suggestion of the digital divide index as a measure of social inequalities in the adoption of ICT.

**Figure 4. Time distance (S-distance) in months from the EU15 average for April 2002 for percentage of computer usage**

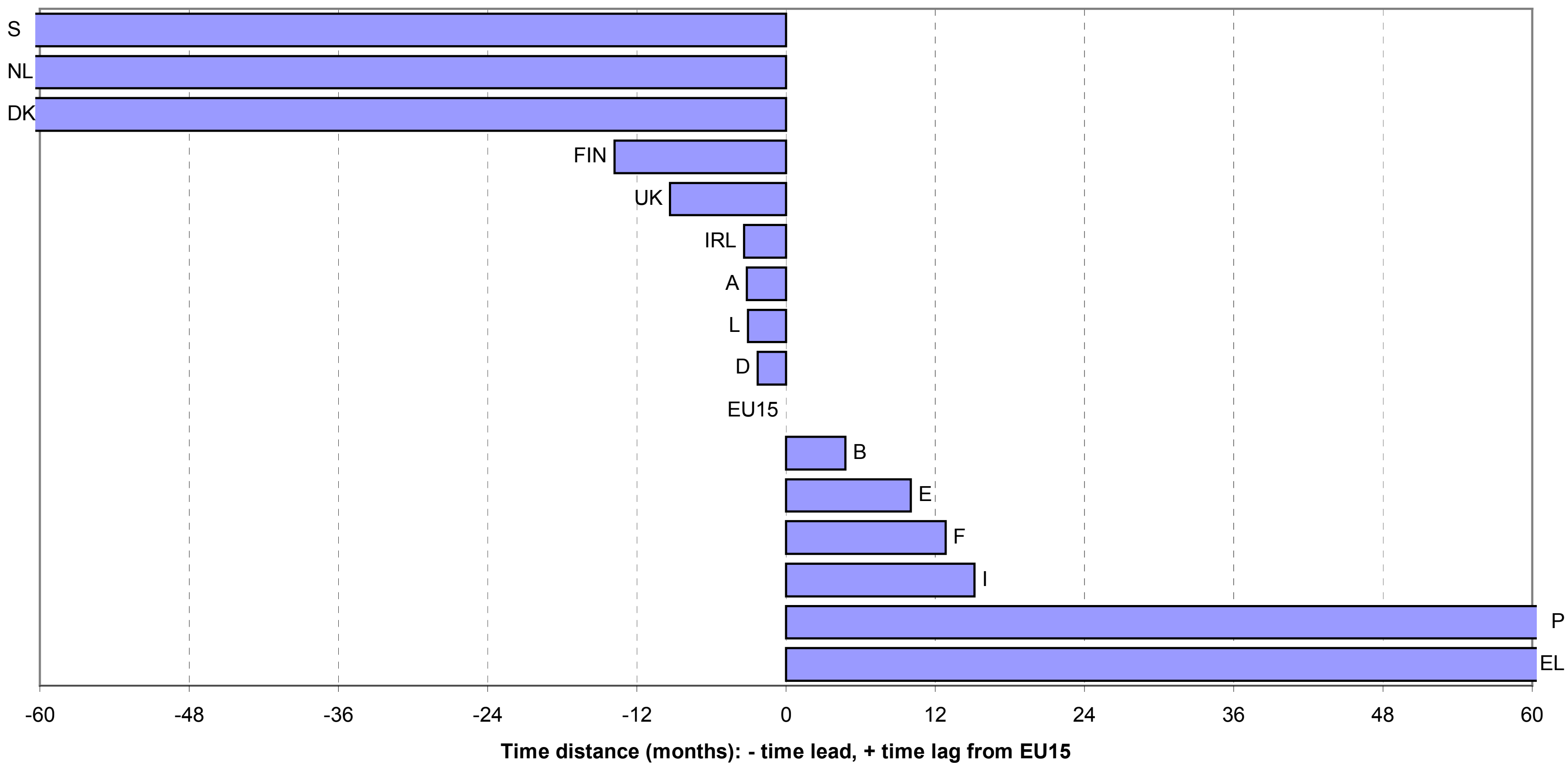

**Table 11. Time (months) in which the specified level of computer usage was achieved in each country (interpolation)**

| Level | B | DK | D | EL | E | F | IRL | I | L | NL | A | P | FIN | S | UK | EU15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | |
| 20 | | | | Jan-98 | | | | | | | | Sep-97 | | | | |
| 25 | | | | Jun-01 | | | | | | | | Jun-00 | | | | |
| 30 | | | | | | | Aug-98 | | | | | Sep-01 | | | | |
| 35 | May-98 | | Jan-98 | | Mar-01 | Sep-99 | Aug-00 | Feb-00 | | | | | | | | |
| 40 | May-00 | | May-00 | | Aug-01 | Jun-01 | Jan-01 | Oct-01 | | | Nov-00 | | | | | May-00 |
| 45 | May-01 | | Feb-01 | | Jan-02 | | May-01 | | Oct-00 | | Mar-01 | | Jul-97 | | | Mar-01 |
| 50 | Dec-01 | | Jul-01 | | | | Aug-01 | | May-01 | | Jul-01 | | Jun-99 | | Dec-00 | Sep-01 |
| 55 | | | Dec-01 | | | | Nov-01 | | Nov-01 | | Nov-01 | | Dec-00 | | May-01 | Feb-02 |
| 60 | | | | | | | Mar-02 | | | | Apr-02 | | Jun-01 | Apr-97 | Oct-01 | |
| 65 | | Nov-00 | | | | | | | | Mar-01 | | | Dec-01 | May-99 | Feb-02 | |
| 70 | | Nov-01 | | | | | | | | | | | | Mar-02 | | |

**The second example is a comparison for one unit (EU15 average or one country) over two indicators (total internet usage TIU and total internet usage at home TIUH) and over all the analysed categories (various aspects of within country digital divide).** The empirical values in this example are those for digital divide for EU15 average for total Internet usage. Obviously, the same analysis can be made for each of the 15 countries separately. For the latest available data for EU15 average (April 2002 SIBIS Survey) the time distances for the disadvantaged categories compared against the average value for each indicator for a given country are presented in Figure 5. In this figure, the average value for EU15 of total Internet usage TIU is used as the basis of comparison for all categories of Internet usage and of Internet usage at home. These values of time distances in Figure 5 are easy to comprehend. They can also be compared later across countries and indicators, which is another good characteristic of time distance methodology[8]. The time distances presented here are expressed in months, but can be rephrased in years or days.

The time matrix in Table 12 is another example of the simplest form of combining information with respect to time and levels in a single table, which can be applied in a generic form across many indicators. The higher on the level scale is a category within the five columns related to the respective categories for a given indicator, the smaller the time dimension of the digital divide. The ranking of the digital divide by the categories in this table is obvious: the smallest is for gender, followed by age (+50), income (1st quartile) and low education (people who finished formal school education at an age of 15 years or below). In this table one can compare that by levels over the whole period. Indicators having the same unit scale (like penetration rates, etc.) may be compared in the time distance perspective also among themselves, provided that this makes sense from a substantive point of view. In the case of data on digital divide it is interesting to see the time lags between total computer usage, total Internet usage and total Internet usage at home, since they are increasing in that order (and can also be repeated for other groups). Here two possible cases are mentioned.

If one takes total Internet usage as a base, Table 12 shows that the total computer usage is leading indicator, and total Internet usage at home is lagging that indicator. For total usage the lead of total computer usage was about 7 months, and lag for total home Internet usage behind total Internet usage was about 8 months. The corresponding figures for female groups were approximately 8 months in both cases at the respective attained penetration rates. This is a rather interesting information format also for market research. Obviously such an analysis can be undertaken for all EU15 countries and for other groups and then compared both within countries by categories as well as for a given aspect of digital divide among countries.[9]

**8** For instance, if looking at the respective graphs for Germany one could see that time lag for the disadvantaged categories is in Germany in nearly all cases less than in the EU15.

9 Sicherl (2000) presents a case of digital divide for penetration rate for computers in households in the USA by income and education level.

**Figure 5. Digital divide in EU15 in time (S-distance): how many months earlier was the level of selected categories in 2002 attained by average Internet usage**

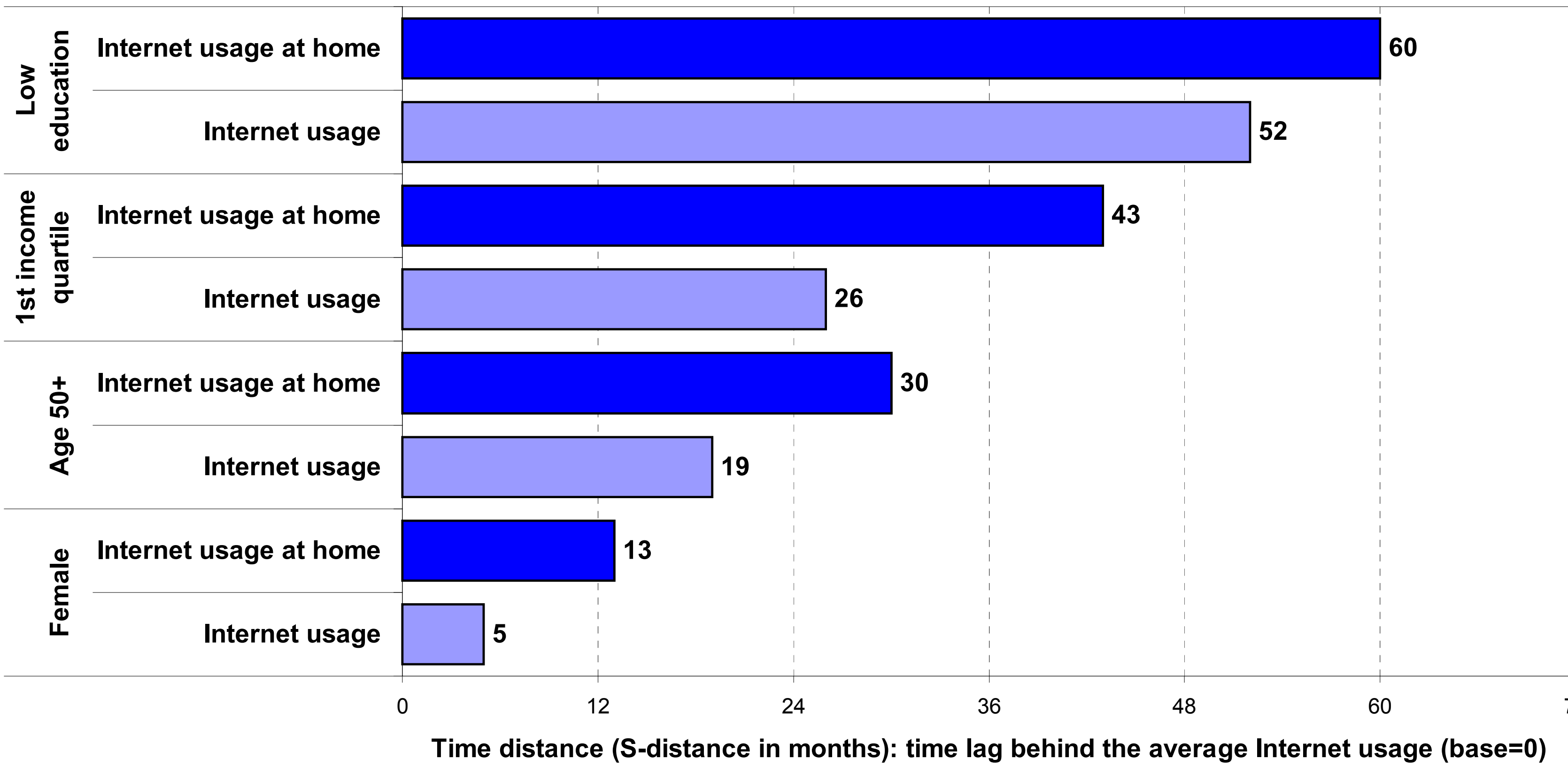

**Table 12. Time matrix: time when a specified level of the penetration rate was attained by the selected categories**

| *Level* | *TCU* | *50+CU* | *FCU* | *1stQCU* | *EDUCU* | *TIU* | *50+IU* | *FIU* | *1stQIU* | *EDUCIU* | *TIUH* | *50+IUH* | *FIUH* | *1stQIUH* | *EDUCIUH* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | | | | | Jan-98 | | Aug-97 | Sep-99 | Mar-97 | Feb-99 | Jul-97 | Apr-98 | Aug-00 |
| 10 | | | | | | Aug-97 | Nov-00 | Mar-98 | Feb-99 | Oct-01 | Jul-98 | Feb-01 | Mar-99 | Sep-00 | |
| 15 | | | | | May-01 | Aug-98 | May-01 | Jun-99 | Sep-00 | | Oct-99 | Aug-01 | Oct-00 | Feb-02 | |
| 20 | | Jan-01 | | Sep-98 | | Sep-99 | Oct-01 | Aug-00 | Oct-01 | | Nov-00 | Mar-02 | Mar-01 | | |
| 25 | | Aug-01 | | Oct-01 | | Sep-00 | Apr-02 | Feb-01 | | | Apr-01 | | Aug-01 | | |
| 30 | | Feb-02 | | | | Jan-01 | | May-01 | | | Aug-01 | | Jan-02 | | |
| 35 | | | Aug-00 | | | May-01 | | Sep-01 | | | Jan-02 | | | | |
| 40 | May-00 | | Apr-01 | | | Sep-01 | | Jan-02 | | | | | | | |
| 45 | Mar-01 | | Oct-01 | | | Dec-01 | | | | | | | | | |
| 50 | Sep-01 | | Mar-02 | | | Apr-02 | | | | | | | | | |
| 55 | Feb-02 | | | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | | | | |

## Legend

| | | | | | |
|---|---|---|---|---|---|
| TCU | Total computer usage | TIU | Total Internet usage | TIUH | Total Internet usage at home |
| 50+CU | Computer usage for age 50+ | 50+IU | Internet usage for age 50+ | 50+IUH | Internet usage for age 50+ at home |
| FCU | Computer usage female | FIU | Internet usage female | FIUH | Internet usage female at home |
| 1stQCU | Computer usage 1st income quartile | 1stQIU | Internet usage 1st income quartile | 1stQIUH | Internet usage 1st income quartile at home |
| EDUCU | Computer usage low education | EDUIU | Internet usage low education | EDUIUH | Internet usage low education at home |

## 6. Conclusions

From the methodological point of view, it can be claimed that these examples proved that there are several types of time distance analysis that can be very useful as an additional insight into analysis of digital divide, especially as a presentation and communication tool. The novel time distance methodology is immediately operational and such analysis can be used as an important additional dimension to the present state-of-the-art of comparative analysis and consequently as an additional input into policy debate and decision making process at various levels.

While digital divide is an important policy issue in many countries and in global terms, within the European Union it is given a special emphasis stemming from the Lisbon Strategy. Lundvall (2000) underlined two important characteristics of the emerging knowledge based economy: the major impact of the information technology revolution is that it speeds up the process of change in the economy, while the most important inherent contradiction of the learning economy has to deal with polarization and social exclusion. It is in this light that now, more than ever, there is also a need that the conceptual and statistical framework employed to deal with the problems of interrelationship between growth and inequality goes beyond the conventional static approach and provides a broader dynamic framework for policy analysis and debate.

The empirical examples cover three among many possible applications of time distance methodology with regard to the analysis of digital divide. In the first case all the three measures of the gap in Internet users per capita (absolute difference, percentage difference and S-distance) show three different conclusions about the directions of the change of the gap between North America and Western Europe/Scandinavia for the period 1998-2005. The absolute difference is approximately constant; percentage difference is decreasing, while time distance is increasing. The apparent paradox of such a surprising and counterintuitive conclusion is explained by the fact that static measures at a given point in time are comparing regions at different points in their logistic curves. The broader methodology taking into account all three measures easily explains the apparent paradox and confirms that the theoretical position that static and time distance measures can lead to very different conclusions is important in real life situations and not only as a theoretical rarity.

The analysis of differences for the indicator personal computers per 100 inhabitants for 25 European countries, the USA and Japan confirm for another type of analysis that more additional insights can be attained if the usual static measures of disparity are complemented by the distance analysis. It is a natural complement to the conventional static analysis expressed in time units that can be easily understood by everybody. As such is time distance an example of a standardised statistical measure, since time units can be compared across different indicators and different units of comparison.

By generalisation, the novel broader dynamic conceptual and statistical framework can be expected to enhance the analysis and perception of the gap between two or more units like countries, regions, cities, sectors, attributes, firms or economic and social groups. The latter case is presented in the section where time distance analysis is applied to survey results on digital divide in the EU. The first case deals with time leads and lags from the EU15 average for the indicator computer usage showing the broad range of dispersion in time between the leading and the lagging countries. The second case is an example to analyse time distances between the average value of total Internet usage and the values for different population categories. The ranking of the digital divide for time distance measure by these categories showed that the smallest lag is that for gender, followed by age (+50), income (1stQ) and low education. Furthermore, one can compare penetration rates for different indicators and different categories. For instance, the total computer usage is leading indicator, and total Internet usage at home is lagging that indicator. For total usage the lead of total computer usage was about 7 months, and lag for total home Internet usage behind total Internet usage was about 8 months; such information format expressed in time units may be of interest also for market research.

Obviously such an analysis can be repeated for all EU15 countries and for other selected groups and then compared both within countries by categories as well as among countries for a given aspect of digital divide. All examples showed that time distance did not replace the existing measures and analysis, but only added a universally understandable dimension to the gap analysis. In addition to that substantive benefit, being expressed in units of time makes time distance an excellent presentation tool understandable to politicians, managers, media and the general public.

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