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The real voyage of discovery consists not in seeking new lands but in seeing with new eyes.
Marcel Proust

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Time is one of the most important reference frameworks in a modern society. People compare over many dimensions and over time. However, the present-state-of-the-art of comparative analysis lacks both the theoretical framework and statistical measures to try to deal with time perspective. With the notion of time distance this perspective is systematically introduced both as a concept and as a quantifiable measure.

In the broader theoretical framework the degree of disparities is measured in two dimensions: proximity in indicator space and proximity in time, which may lead to very different perceptions. 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. Two concepts, degree of inequality and convergence, will be redefined and broadened. The novelties in conceptual and statistical framework will have important policy implications, especially for interrelationship between efficiency, growth and inequality. Empirical examples will show that new insights and conclusions can be reached from innumerable existing time series databases.

Key words: comparisons, time distance, S-distance, inequality, convergence

JEL classifications: C10, O10, O57

1. Introduction

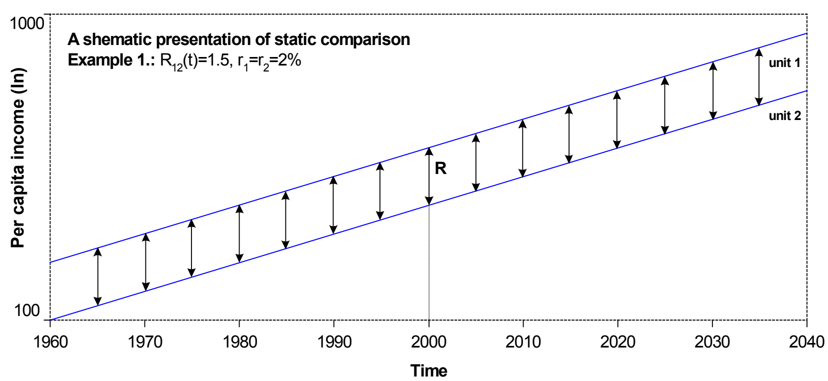
In research and decision-making process comparisons play an important role. The better the analytical framework the greater the information content provided to experts, policy makers and general public. The present state-of-art of comparative analysis, over many dimensions and over time, needs improvement at least in two directions: (1) comparisons over indicator space and over time need to be better integrated, (2) an explicit treatment of the time dimension as a universal unit of measurement can establish a special category of time distance as one of the measures of disparity thus contributing new insights to comparative analysis.

Section 2 defines time distance as a novel generic statistical measure complementing the conventional static measures of disparity and thus exploiting the information content in the data that was left unidentified until now. In section 3 characteristics of static and time distance measures are compared. The two-dimensional notion of the overall degree of disparity provides new insight from existing data as section 4 shows also empirically that this can bring a very different perception of the extent of disparity across indicators with different dynamic characteristics. Furthermore, the growth rate effect leads also to a broader notion of convergence or divergence in section 5. The empirical examples confirm that the two-dimensional comparative analysis adds new insight while none of the earlier results are lost or replaced.

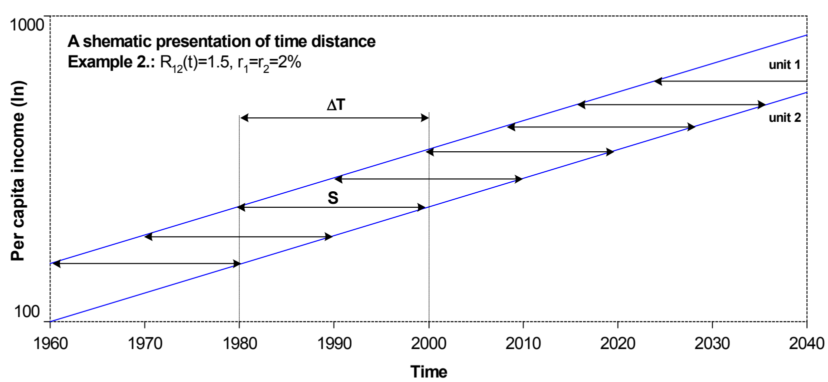
2. A Novel Generic Statistical Measure: Using Levels of the Variable as Identifiers and Time as the Focus of Comparison and Numeraire

Time distance analysis requires a radical shift in perspective with respect to time series data. Under the conventional perspective, comparisons are made on the basis of absolute or relative values of a given socio-economic indicator for each point in time, i.e. the main emphasis lies in the differences between two time series data at each point in time, respectively. The new perspective on time series, which for obvious reasons can be characterized as 'temporal', has its main focus on the horizontal differences in time for each level of socio-economic indicators for the two or more compared units. Under the new focus, time distance measures the differences in time for specified levels of the indicator. The observed distance in time (the number of years, quarters, months, etc.) is used as a temporal measure of disparity between two time 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. It is remarkable that the notion of time distance, which can be in principle developed from the same information embodied in the existing data, has not been earlier developed theoretically and as a standard statistical measure.

Figure 1. Perceiving and measuring differences in two dimensions (in value and in time)



1. Static dimension: difference in value at a given point in time



2. Time dimension: difference in time for a given value of the indicator

Figure 1 presents the idea for a simple case where the chosen indicator (in this example GDP per capita) is growing at the same rate of growth in both compared units. This is by no means a necessary requirement; it serves only an immediate purpose to explain in Figures 1 and 2 the main impact of the novel theoretical and analytical framework for comparative analysis in simple, though not simplistic terms.

First, a broader theoretical framework is required. Time distance concept and methodology represent an inherent dimension in comparative analysis over time. The conventional approach does not realise that in addition to the disparity (difference, distance, proximity) in the indicator space at a given point in time, in principle there exist a theoretically equally universal disparity (difference, distance, proximity) in time when a certain level of the indicator is attained by the two compared units. A new dimension is added while no earlier results are lost or replaced.

Second, a statistical measure S-distance is defined to suggest a possibility how the broader concept and reference framework can be measured in operational terms and how they can be integrated with the conventional statistical measures. Time distance in general means the difference in time when two events occurred. A special category of time distance related to the level of the analysed indicator is defined: 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.

The standpoint that time distance measure is a generic concept of comparative analysis similar to the conventional concepts of static disparity measure(s) and growth rate can be presented in two ways, the first one is presented in Table 1. The first two rows in Table 1 describe data requirements for two statistical measures that deal with direct comparison of values of the indicator for the two compared units. We compare two points with three elements of information: (i) the respective level of the indicator, (ii) to which unit it belongs, and (iii) at what time it happened. The first row represents the static type of comparison between two units at a given point in time (e.g.. absolute difference, ratio, percentage difference), where time and unit serve as identifiers and the disparity in the indicator space is measured. For the novel statistical measure S-distance in row two, following the same logic, a given level is the same for both units, level and unit serve as identifiers, and time is used as numeraire for calculating time distance.

Table 1. Points of comparison for static difference, change over time and time distance (Comparing two units)

	TIME	LEVEL	UNIT	Measure
TIME	same	2	2	static difference
LEVEL	2	same	2	time distance
UNIT	*2*	*2*	*same*	*change over time*

Using the comparison between two units in Table 1 as an example, it is shown that the idea of time distance goes together very naturally with the existing concepts of static disparity at a given point in time and the notion of the growth rate over time. Time has been used in comparisons mainly as locational 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, then a given level of the indicator becomes a descriptor or identifier and 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, the time distance is the priority choice because of its intuitive nature, and of the importance of the time dimension in semantics of describing various situations in real life and forming our perceptions about them (Sicherl 1997b).

If we describe static difference and time distance in terms of operators, then for static difference(s) follows

absolute difference

$$A_{ij}(t) = X_i(t) – X_j(t)$$

ratio

$$R_{ij}(t) = X_i(t)/X_j(t)$$

percentage difference

$$P_{ij}(t) = [X_i(t)/X_j(t) – 1]*100$$

In case of time distance, for a given level of X_L, $X_L = X_i(t_i) = X_j(t_j)$, the S-distance, the time span separating unit (i) and unit (j) for the level X_L, will be written as

$$S_{ij}(X_L) = \Delta T(X_L) = T_i(X_L) – T_j(X_L) \qquad (1)$$

where T is determined by X_L. In special cases T can be a function of the level of the indicator X_L, while in general it can be expected to take more values when the same level is attained at more points in time, i.e. it is a vector which can in addition to the level X_L be related to time. Three subscripts are needed to indicate the specific value of S-distance: (1 and 2) between which two units is the time distance measured and (3) for which level of the indicator (in the same way as the time subscript is used to identify the static measures). In the general case also the fourth subscript would be necessary to indicate to which point in time it is related ($T_1,T_2,...,T_n$).

The sign of the time distance comparing two units is important to distinguish whether it is a time lead (-) or time lag (+) (in a statistical sense and not as a functional relationship)[1]

$$S_{ij}(X_L) = -S_{ji}(X_L) \; . \qquad (2)$$

For a given level of the indicator X_L in general there will be two vectors of the values of time when this level of the indicator (or its approximation by interpolation or extrapolation) will be attained by unit i and unit j: $T_i(X_L)$ with m values and $T_j(X_L)$ with n values. The corresponding matrix of time distances will have m times n

[1] The earlier definition of S-distance (see e.g. Sicherl, 1978 and 1992) used positive sign for time lead and negative sign for time lag. With the generalisation of application of the time distance concept and S-distance measure to short term economic analysis (e.g. deviations in regressions, models, forecasting and monitoring) in Sicherl (1994), for a more clear two-dimensional graphical presentation of deviations between actual and estimated values it was found to be more convenient to assign the negative sign to time lead and positive sign to time lag, as it is done in equations (1) and (2).

elements. For continuously increasing or decreasing series there will be only one time distance value.

On the theoretical level the time distance approach provides a new view of information: it uses level of the variable(s) as identifiers and time as the focus of comparison and numeraire. Time distance is a generic concept, like percentage difference or growth rate[2]. Events are dated in time, therefore in time series comparisons, regressions, models, forecasting and monitoring, the notion of time distance was always there as a "hidden" dimension. In such capacity it can be used to analyse a variety of problems beyond the applications in this paper, which are focused on comparisons between countries[3].

It can be generalised to other types of applications, like analysis of discrepancy between the estimated and actual values and goodness-of-fit in time series, regressions and models, forecasting and monitoring[4], and extended to variables other than time. However, there is no space to elaborate on the generic characteristics of the time distance concept in this paper.

There are at least four ways in which one can read off or estimate the values of S-distance for the past. The first one simply compares data in the table, then for a given value (level of the indicator) finds the two points in time indicating when such indicator value was achieved in the two compared units, and subtracts the time values to arrive at the value of S-distance. This is simply a statistical fact and one does not need to bring into the picture any assumptions about the respective rates of growth or catching-up hypothesis. For instance, in Table 2 the level of female life expectancy of 75 years was achieved in Sweden about 1960 and in the UK in 1970, which means, that this level of the indicator was attained in Sweden ten years earlier, so that S-distance for this level is –10 years time lead for Sweden, or 10 years time lag for the UK.

The second method is similar, one can select a given level of the indicator from a figure of trends of the compared series, read off from the figure the respective times for the given level of the indicator and calculate the corresponding time distances. This is schematically presented in the lower part of Figure 1. However, Figure 2 shows this for a practical example of calculating backward looking S-distances from the EU average for GDP per capita for the candidate countries in the HWF project. The left part of Figure 2 presents the calculation of the respective time distances for the levels of GDP per capita of these countries for the year 2000. According to

[2] For elaboration of this statement see e.g. Sicherl (1999), which also presents the extension of the concept to variables other than time.

[3] Within the 5th Framework Programme of the EU research programme, SICENTER is a member of the consortium for the project Households, Work and Flexibility (http://www.hwf.at). The numerical examples based on data from Sweden, UK, Slovenia, Czech Republic, Hungary, Bulgaria and Romania, which are all members of this consortium, are being used in the comparative stage of the project for the purpose of analysis of the country backgrounds.

[4] The extension to measuring deviations between estimated and actual values in time distance for regressions and models, for forecasting and monitoring and for business cycle analysis see Sicherl (1994, 1998). Granger and Jeon (1997) mention that 'Sicherl's several works have presented a non-technical discussion of the theory of time distance. This concept can help us to think more clearly about the forecastibility of series.' In the paper they present the formalization for the case of comparing lagged or leading indicators and conclude that in modeling series with leading or lagging indicators, it is desirable to begin comparing models in terms of time distance.

Eurostat, the level of GDP per capita (at purchasing power parity) in 2000 amounted to 69% of the EU15 average for Slovenia, 59% for Czech Republic, 51% for Hungary, 28% for Bulgaria, and 23% for Romania.

The logic of calculation of the backward looking (ex post) S-distance can be observed if in the historical time series for EU15 one looks for the year in which the EU15 had the same percentage of its 2000 value of GDP per capita as Slovenia had in 2000. This was approximately in the year 1982, which means that the backward looking time distance is about 18 years. In other words, the same value of the analysed indicator was achieved in EU15 18 years ago (1982 compared to 2000 in Slovenia). The corresponding values are for Czech Republic 28 years, for Hungary 31 years. The value for EU15 average in 1960 was 36% of its value in the year 2000, which means that the present values of GDP per capita for Bulgaria and Romania are lower than that and thus the backward looking S-distance is greater than 40 years.

Figure 2 is also used as an empirical example of an important distinction between backward looking (*ex post*) and forward looking (*ex ante*) time distances. They relate to different periods, past and future. The first belongs to the domain of statistical measures based on known facts; the second is important for describing the time distance outcomes of the results of alternative policy scenarios for the future.

In this paper we will use mainly the backward looking time distances, i.e. the time distances will be used in the descriptive role to express the development gaps between selected countries in this additional perspective. In such application the time distance for the past period will introduce additional information about the fact at what point in time for a given indicator the benchmarking country, region or other unit observed the same level of the indicator that the compared unit is experiencing at present. This gives us the information about the magnitude of lead (lag) in time between the two compared units for a given level of the indicator. This information is independent of the static difference or the rate of growth; it is a statistical fact reflecting one of the possible perspectives on the magnitude development gap. Thus it can serve as an additional analytical method in numerous areas and for numerous indicators.

In the right hand side of Figure 2 forward looking S-distance for the level of EU15 average for 2000 are calculated based on a scenario that GDP per capita for the candidate countries will grow at 4 per cent per year. If this scenario would be implemented, the level of EU15 average for 2000 would be reached by Slovenia at about 2010, which means that at this level of GDP per capita the time distance for Slovenia would be about 10 years. Since we do not have the scenario for growth of GDP per capita for EU15 average in the future, it is with this single assumption not possible to calculate what will be the conventional absolute or percentage difference between EU15 average and Slovenia in 2010. However, under the assumed scenario we have the estimate of one dimension of disparity in 2010, the time distance is expected to be about 10 years. Such scenario tells us that the time dimension of disparity between Slovenia and EU15 average is expected to be reduced from 18 years to 10 years. Under the assumed scenario for growth rate for the candidate countries, the respective projected S-distances for the level of EU15 average in 2000 would be 14 years for Czech Republic, 17 years for Hungary, 33 years for Bulgaria and 38 years for Romania. Such a calculation of how many years would be needed for

Table 2. Illustrative example: GDP per capita and female life expectancy for Sweden and the UK, 1960-1998

GDP per capita			Female life expectancy		
Year	Sweden	UK	Year	Sweden	UK
1960	8688	8645	1960	74.9	73.7
1970	12716	10767	1970	77.1	75
1980	14936	12928	1980	78.8	76.2
1990	17680	16411	1990	80.4	78.5
1998	18685	18714	1998	81.9	79.7

Source: for GDP per capita, 1990 international Geary-Khamis dollars, Maddison (2001), for female life expectancy, Eurostat (2001)

Table 3. Illustrative example: GDP per capita and female life expectancy for Sweden and the UK, 1960-1998; S-distance (- time lead, + time lag) and time intersections for specified levels of GDP per capita and of female life expectancy

GDP per capita				Female life expectancy			
GDP per capita level (int. dollars)	Sweden time	UK time	S-distance (years)	Female life expectancy level (years)	Sweden time	UK time	S-distance (years)
8000				73			
9000	1960.8	1961.7	-0.9	74		1962.3	
10000	1963.3	1966.4	-3.1	75	1960.5	1970.0	-9.5
11000	1965.7	1971.1	-5.3	76	1965.0	1978.3	-13.3
12000	1968.2	1975.7	-7.5	77	1969.6	1983.5	-13.9
13000	1971.3	1980.2	-8.9	78	1975.3	1987.8	-12.5
14000	1975.8	1983.1	-7.3	79	1981.3	1993.3	-12.1
15000	1980.2	1986.0	-5.7	80	1987.5		
16000	1983.9	1988.8	-4.9	81	1993.2		
17000	1987.5	1992.1	-4.5	82			
18000	1992.6	1995.5	-3.0				

Source: own calculations based on data in Table 2

Figure 2. Past time distances and time distances (projected) at the level of EU15 average GDP per capita for 2000 (Scenario: growth rate in selected countries is 4%)

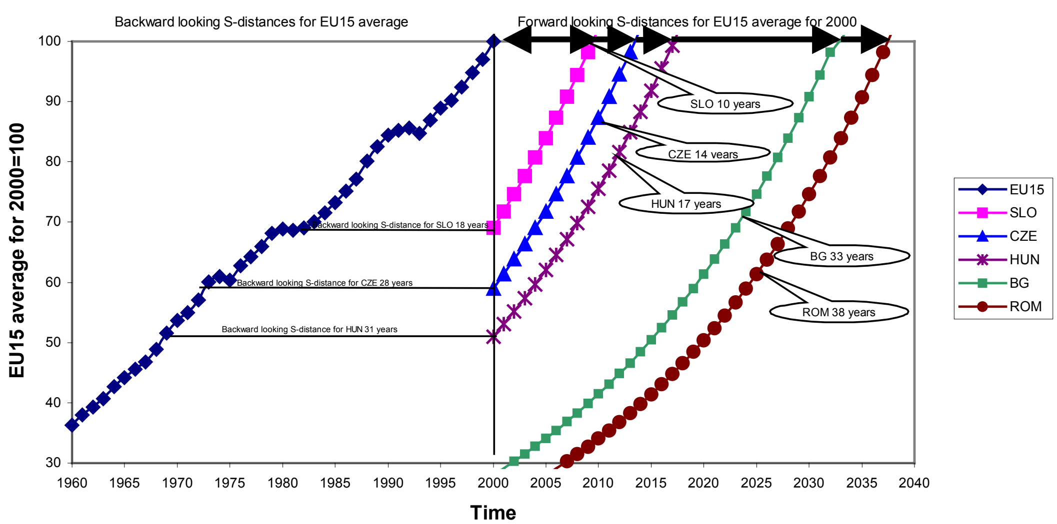
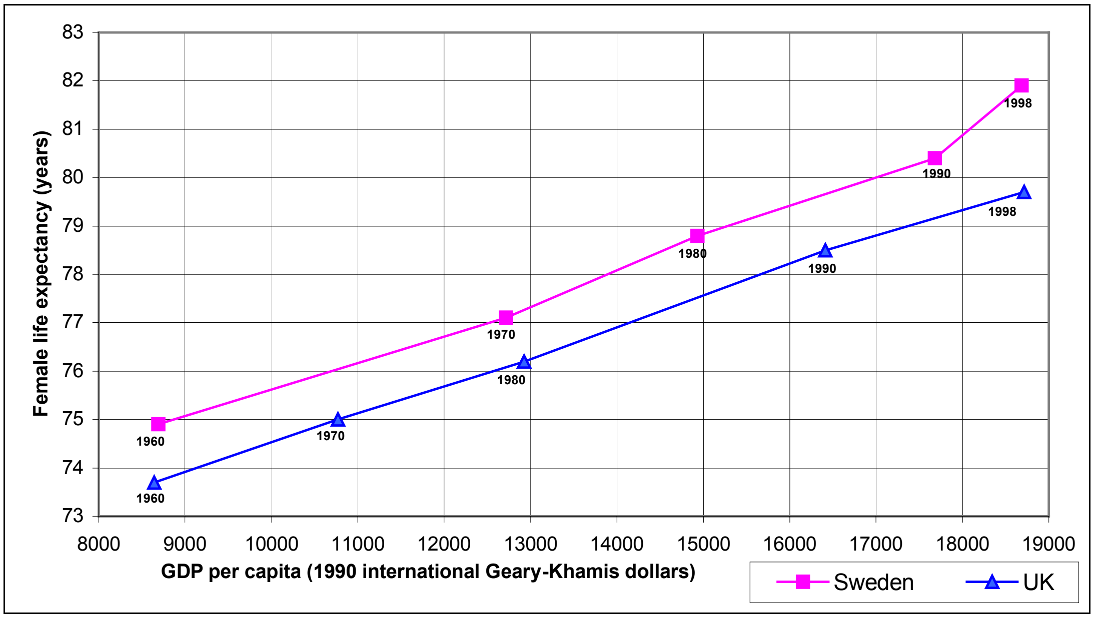


Figure 3. Scatter diagram of relationship between GDP per capita and female life expectancy for Sweden and the UK, 1960-1998



Data source: Maddison (2001), Eurostat (2001)

these countries to reach a given level (in our case EU 15 average for 2000) is a simple exercise in algebra, which is commonly used in describing such issues. However, within the framework of time distance methodology these values have also an additional meaning; they represent estimated future time distances for a given level of the indicator under the selected scenario[5].

The third method is an extension of the second method to the X – Y scatter diagram. For any selected level of the indicator (X or Y in our simple example) one needs only to subtract the time subscripts for the two compared units for that level of the chosen indicator to obtain the respective time distance. In an X – Y scatter diagram like Figure 3 the information on time is usually not fully utilised by the commonly applied statistical methods. If one would use regression analysis, one could estimate the slope and the intercept of the relationship between X and Y for the two units, and also further test the significance of difference between the parameters for Sweden and for the UK. For the estimate of the slope it would be irrelevant whether the first point relates to the year 1960 or 1998, which shows that the information about the time subscript is not utilised. However, if one applies the generic idea that time subscripts cannot be used only as identifiers, but also as values ('numeraire') in the implicit time framework as the third dimension beyond the XY dimensions explicit in the diagram, the time distances implied become visible. For instance, looking horizontally for the value of 75 years of female life expectancy, one can subtract the time subscript for Sweden 1960.5 and for the UK 1970 (see Table 3) and arrive at time lag for the UK of about 10 years. Table 3 contains the calculations of other time distances for a given level of either indicator that are alternatively observed in Figure 3.

[5] This provides for estimate of the future value of the time dimension of the disparity. If one would wish to project also the static relative disparities with EU15 in the future, one would need a second assumption about the future rate of growth of EU15 average.

In all three methods of estimating time distance mentioned, S-distance is calculated from original data (with some possible interpolation and extrapolation) without referring to any other information than levels of the indicator and time subscripts. This is a confirmation of the statement that one deals with the (n+1) dimension in a multidimensional space of n variables, which was always there but left unexplored.

The fourth possible method of estimating the value of S-distance is based on a possible integration of static and intertemporal comparisons. When the respective measures relate to the appropriate period and levels, the relationship is obvious

$$S_{ij}(X_L) = \ln R_{ij}(t)/r_i\,,$$

where r represents the corresponding average rate of growth, and R represents the static ratio between the values of the indicator for the two units at time (t). This method is particularly useful for calculation of forward looking time distances, although it can be used also as an approximation in calculating backward looking time distances. For backward looking S-distance the corresponding average rate of growth is that of the more developed unit r_i, for forward looking S-distances it is the average rate of growth of the indicator for the less developed unit in the future r_j. To calculate the time needed for full equalization the result depends on the initial static disparity and the difference between the two growth rates:

$$SE_{ij} = \ln R_{ij}(t)/(r_j - r_i)\,.$$

There are several other extensions of the time distance conceptual and analytical framework presented so far. One possible extension is an additional time related measure that is derived from the values of time associated with a given level of the indicator in Table 3 labelled in this example as Sweden time and UK time. The vertical differences from the time associated with the consecutive levels of the indicator can be labelled as time steps and can be used as an alternative description to the growth rate concept. Coming back to the example in Table 1, the third row measures the dynamic properties of the indicator, like growth rate, for each unit separately. Now unit is the same and from information on two levels at two different times the growth rate for that unit over the respective period can be calculated. It is important to underline that the nature of the measure of change over time is different from that of static difference and time distance. The latter are measures of direct comparison of indicator values between two or more units, while the growth rate is an example of a measure of a joint characteristic of several points for the given unit.

Slope

$$\Delta X/\Delta t\,(t) = (X_t - X_{t-1})/\Delta t$$

Using the table of the inverse relation, a corresponding measure in units of time would be

$$\Delta t/\Delta X\,(X) = (t_t - t_{t-1})/\Delta X$$

We shall not elaborate on this measure here due to lack of space[6]. Similarly, the concept of time distance for a given level of the indicator can be applied also to variables other than time (Sicherl 1999).

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[6] See Sicherl (2000) for the interpretation how different statistical measures of the gap between North America and Europe in Internet users per capita show diverse conclusions.

3. Comparing Some Characteristics of Static and Time Distance Measures

As the time distance is in our case defined for a given level of the indicator, it should be emphasised that in principle time distance is independent of the static distance(s) for a given point in time. Two time series (e.g. actual and estimated values of the analysed indicator X[7]) can be analysed independently from two perspectives: for a given point in time one gets static discrepancies, for a given level time distances as discrepancy in timing. If for the moment we look at these two types of comparisons as separate and independent procedures, one can see certain advantages and disadvantages of the two approaches.

The advantage of comparisons at a given point in time lies in the fact that, for the known length of the two time series, all values can be determined as a single value for any given point in time. For comparisons at a given level of the indicator, time distance cannot be determined (without extrapolation or interpolation) for those levels of the indicator which were not reached by both series. Also, it is possible that for the same level of the indicator there are multiple crossings and the analysis of time distances becomes more complex. On the other hand, if the two time series are continuously increasing or decreasing, when defined also for time distances one gets single values only for a given level of the indicator.

In general, while the levels or static differences can be written as a function of time, time intersections and time distances for a given level of the variable have to be expressed as relations. Thus in the computer programme for calculation of time distances one has the options for calculating them on the basis of the first or last intersection, as an average of all time distances or as a minimum distance. As always, it is for the user to decide which is the most useful for the purpose of the inquiry.

The complexity of possible numerous solutions is diminished by the fact that time distance concept is simple and intuitively straightforward, at the same time there is the benefit that the complexity of the situation is underlined. There are also at least two cases where this characteristic can be used for types of analysis that are not available in the static approach. The first is calculation of time distances for various levels of the indicator on the series itself, which makes no sense in static comparison, but can be a useful device to study some characteristics of time series with considerable fluctuations. In such a case the matrix of time distances for a given level of the indicator is a square matrix and the most interesting cases are the elements above (or below) the main diagonal which represent S-distances between the neighbouring intersections in time. Although the application of S-distance analysis to business cycle analysis, for study of residuals and more generally in analysing stationary series is very interesting, it will not be developed further here for lack of space (an empirical example is provided in Sicherl 1996). The second application can be used to study disparity in a dichotomous 0 or 1 case. Let us suppose that a farmer just got a tractor, and his neighbour did not. After 5 or 20 years the situation would look unchanged from the point of view of static disparity, but the neighbour may be having a rather different perception of disparity after 5 and after 20 years. In other words, in such a case time distance analysis can show a much more fine and differentiated picture of

[7] For extension to measuring deviations between estimated and actual values in time distance for regressions and models, for forecasting and monitoring and for business cycle analysis see footnote 4.

‘various shades of grey’ as opposed to ‘black and white’ description of static measures in such cases.

As mentioned above, the analysis of time distances is a new view of data and a novel data reduction method, it can by itself add interesting new information and can be treated independently of static measures of disparity if one tends to look at the situation from the statistical point of view alone. However, we shall try to integrate them despite some problems in doing this, for details see (Sicherl, 1996).

Technically, depending on the particular form of compromise, it is possible to arrive at a two-dimensional presentation of both static and time distances that can enhance the simultaneous analysis of distances in both dimensions. By the position of a particular point in this type of graph it is possible to determine whether on that particular interval of the curve the indicator has been increasing or decreasing. With time distance on the abscissa, and the respective static distance on the ordinate, the points in the four quadrants can be characterised by the various combinations of values as presented in Table 5 (for details and derivation see Sicherl 1996).

Table 5. Distribution of Time Distances and Static Distances by Quadrants

(x axis = S-distance, y axis = static distance A or ln(R) or percentage P)

II.quadrant	I.quadrant
$S < 0$	$S > 0$
$A > 0$	$A > 0$
$k_T > 0$	$k_T < 0$
III.quadrant	IV. quadrant
$S < 0$	$S > 0$
$A < 0$	$A < 0$
$k_T < 0$	$k_T > 0$

Since k represents the slope of the trends of the values of the indicator for the two units, the second and the fourth quadrant will show the results for increasing functions of time, and the first and the third quadrant for decreasing functions of time (or increasing and decreasing sections of the function). Practical example in this paper is Figure 5 for comparisons over the long run, while examples of application in time series regressions, models, business cycles, forecasting and monitoring are provided e.g. in Sicherl (1997a).

4. The Two-Dimensional Notion of the Overall Degree of Disparity - New Insight from Existing Data

Although the integration of the static and temporal dimensions of disparity into a formally consistent analytical framework can be obtained only as a compromise between the pure concept of comparison at a given point in time and of comparison for a given level of the indicator, we shall use the two-dimensional analysis of disparities across time and space extensively. The advantages of having a broader conceptual framework for a better understanding of the reality far outweighs the disadvantages in dealing with more than one possibility of combining static and temporal distances in a formally consistent analytical framework. Our aim has been to systematise and formalise this novel approach not only on the analytical but also on the conceptual level (see e.g. Sicherl 1978 and 1992). Consequently, we define the concept of the overall degree of disparity (proximity) that is based on a simultaneous perception of proximity in indicator space and proximity in time, as both of them matter.

Figure 4 portrays the position that the overall degree of disparities should be measured in two dimensions; the existing static measures of disparity (proximity) in the indicator space should be complemented by proximity in time. In other words, the difference between the values for the two units could be measured in vertical dimension (the most commonly used are absolute differences expressed in the units of the indicator or relative differences) as well as in horizontal dimension, i.e. in terms of time that leads to the notion of time distance. Such a broader concept of the overall degree of disparity can lead to a different perception of the extent of disparity than the conventional static measures alone.

Figure 4 presents a simple, but not simplistic case of comparing two countries or regions or social groups for a given indicator, assuming two scenarios: scenario A assumes growth rate of 4%, and scenario B growth rate of 1%, for simplicity reasons both units are growing at the same rate of growth, respectively. In the two compared units, the value of the indicator for region 1 is 50% higher than that of region 2 in both scenarios. If one uses for the evaluation of the magnitude of the gap between the two regions the conventional statistical measures like ratio, percentage, Gini coefficient, Theil index, these two scenarios show the same degree of disparity for the two scenarios.

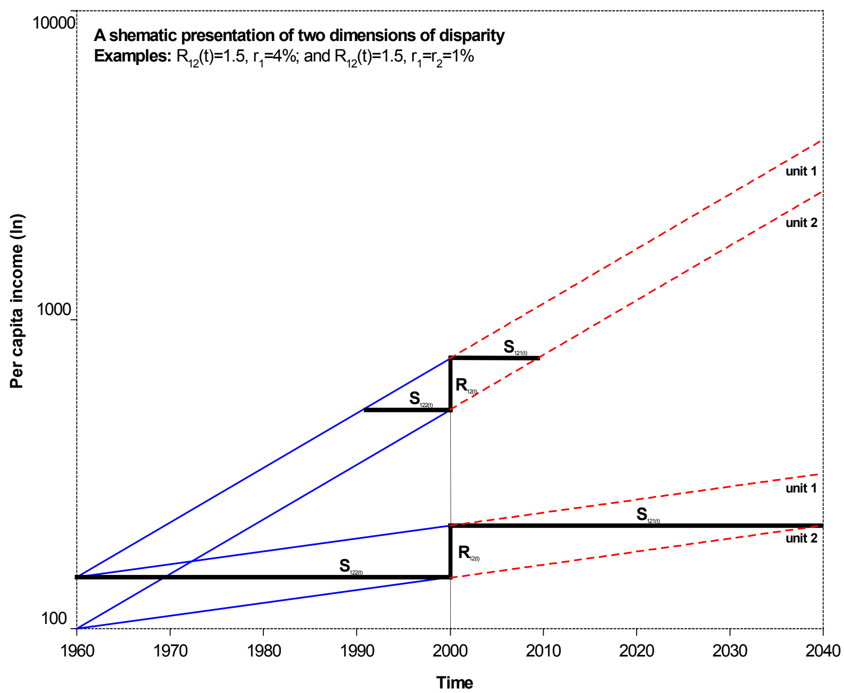
Now let us take a broader view of the situation. The concept of time distance as one of the dimensions of disparity leads to a different conclusion about the degree of disparity in scenario A and in scenario B. In the 4% growth rate for scenario A with the 50% static disparity the time distance between the two regions is 10 years, in scenario B with 1% growth rate the time distance between the compared regions is 40 years. It is highly unlikely that people would perceive such situations as equal degrees of disparity. Conventional welfare theory would need to explain why it would not be possible to incorporate such broader way of thinking and the changed semantics into the present state-of-the-art[8].

The analytical conclusion that higher magnitudes of growth rates lead, ceteris paribus, to smaller time distances, and vice versa, is important in explaining past developments and in preparing policy recommendations. In the dynamic world of today it is hardly satisfactory to rely only on static measures of disparity which are insensitive to the magnitudes of the growth rates and take into account only differences in the growth

[8] Thus one can expect the benefit of an additional descriptive and presentation concept/measure offering a fresh perspective on the situation under scrutiny in all time series applications. Even if this would be the only benefit of its use, it would be unwise not to take advantage of a new analytical tool. Second, important hypotheses about the interrelationship between efficiency, growth and disparity can be formulated in such broader framework with important economic, social and political consequences. This offers improved semantics for analysis and policy debate. For details how the broader concept of the overall degree of disparity can provide new hypotheses for the interrelationship between efficiency, growth and disparity see Sicherl (2001b).

rates between the units. In this respect time distance plays in the analysis of disparities an important role, quite distinct from that of static measures.

Figure 4. Concept of overall degree of disparity: simultaneously perceiving and measuring differences in two dimensions (in value and in time)



Static relative disparity and time distance:
higher (4%) growth example R=1.5, S=10 years;
lower (1%) growth example R=1.5, S=40 years.

Table 6 and Figure 5 present an empirical example of the statement that static measures of disparity and time distance measure can lead to very different analytical and policy conclusions. The position of Slovenia, one member of the consortium for the project Households, Work and Flexibility, is in this example compared to the EU15 average for a set of ten selected indicators. For each of the indicators backward looking S-distance was calculated for the level of the indicator in Slovenia at around 2000. Similarly, static relative disparity was calculated where the value for the EU15 was expressed as an index, the value for Slovenia being 100. This set of economic, social, infrastructure and employment indicators shows that the degree of disparity varies very much across indicators and that it also varies very much if one uses as a measure of the degree of disparity the static index or time distance. This can be confirmed by looking at the values in Table 6 in columns 3 (S-distance) and 4 (index SLO=100). The correlation coefficient between the two columns is 0.02, thus indicating no correlation between the static relative disparity and time distance across indicators. The next two columns confirm that by ranking the indicators by the degree of disparity according to both measures used. The nonparametric Spearman rank correlation coefficient amounts to 0.39, which is again not statistically significant.

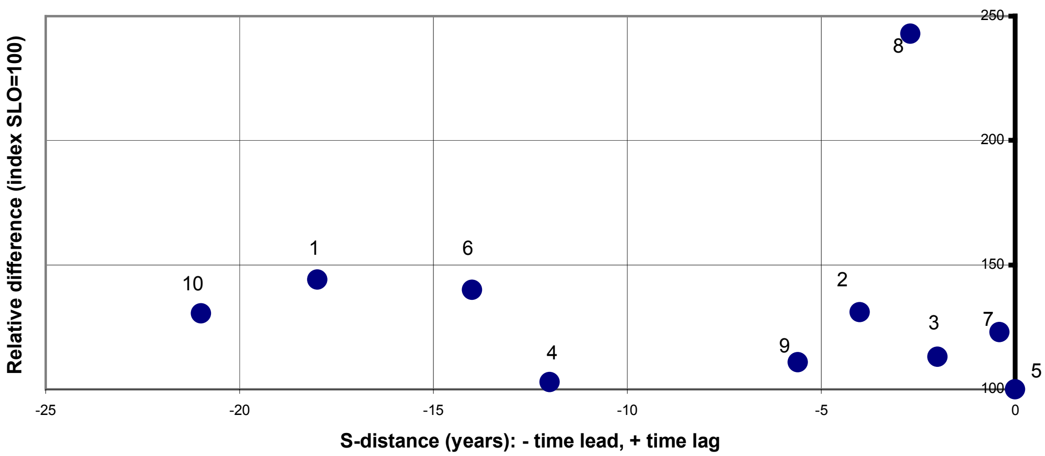
Table 6. Static differences and time differences (- denotes time lead for EU15) between EU15 and Slovenia for selected indicators around 2000, ranking of degree of disparity by these two measures of disparity.

No.	Indicator	S-distance (years)	Index (SLO=100)	Rank S	Rank R
1	GDP per capita (ppp)	-18	144	2	2
2	Exports per capita	-4	131	6	4
3	Imports per capita	-2	113	8	7
4	Life expectancy (female)	-12	103	4	9
5	Infant survival rate	0	100	10	10
6	Telephones per capita	-14	140	3	3
7	Mobile phones per capita	-0.4	123	9	6
8	Internet hosts per capita	-2.7	243	7	1
9	Cars per capita	-5.6	111	5	8
10	Employed in services / total empl.	-21	131	1	5

Source: update of Sicherl (2001a).

The graphical presentation of the two-dimensional analysis of the degree of disparity between Slovenia and the EU15 average is given in Figure 5. Here one can bring to the attention the great difference between the perception of the degree of disparity when measured by static index and time distance best by comparing two extremes in this respect. Life expectancy (female) is in the EU15 only 3% higher than in Slovenia, while the indicator Internet hosts per capita is nearly 2.5 times higher. However, it is questionable whether this static measure of disparity alone could lead to a proper perception of the respective degree of disparity. Time distance however is 12 years for life expectancy (female), and only 2.7 years for Internet hosts per capita, due to very different growth characteristics and the related possibilities how fast the disparities can be reduced. Obviously, for a proper evaluation both dimensions should be analysed simultaneously.

Figure 5. Static difference and time distance between EU15 and Slovenia for selected indicators around 2000



1. GDP per capita (ppp) 2. Exports per capita 3. Imports per capita 4. Life expectancy (female) 5. Infant survival rate 6. Telephones per capita 7. Mobile phones per capita 8. Internet hosts per capita 9. Cars per capita 10. Employed in services / total empl.

5. How The Time Distance Concept Affects the Notion of Convergence or Divergence

Similarly, convergence (divergence) should be discussed in two dimensions: closer (farther) in ratio and closer (farther) in time. In the present usage of the term convergence there is only a simple classification of cases into 'yes' and 'no', where the latter case would include also the case of unchanged relationship. In the above section of the paper it was shown how different dynamic characteristics in different fields of concern as expressed by the respective growth rates change the ranking of indicators by the degree of disparity when measured by static measures or time distances. A similar effect might arise in the analysis of a given indicator when the growth rate is substantially changed between two consecutive periods of development. In this section we shall further briefly explore what such a situation means for a broader notion of convergence and divergence.

Table 7 illustrates a typology of situations when both dimensions, proximity in indicator space and proximity in time, are taken into account simultaneously. One can find in the table 7 that on the diagonal there are the three cases where the static measure and the time distance lead to the same qualitative conclusion, i.e. a unanimous conclusion of convergence or divergence in the sense that the direction of change is the same both in the indicator space and in time. In all other six cases even the conclusion about the direction of change in the two measures is not the same. In such cases it is not easy to evaluate what has happened with the overall degree of disparity, one would need to know people's preferences with respect to the weights given to the static and temporal dimension of disparity.

Table 7: Convergence Viewed in two Dimensions: Proximity in Time and in Space

(3 x 3 classification of cases)

	Distance in indicator space		
Distance in time	1 Ratio ↑ S-distance ↑	4 Ratio = S-distance ↑	7 Ratio ↓ S-distance ↑
	2 Ratio ↑ S-distance =	5 Ratio = S-distance =	8 Ratio ↓ S-distance =
	3 Ratio ↑ S-distance ↓	6 Ratio = S-distance ↓	9 Ratio ↓ S-distance ↓

Table 8 shows an example to prove that these considerations are not just a theoretical rarity but also relevant as an important issue of development policy in the European Union[9]. It shows that the conclusions about convergence of three EU cohesion

[9] One can also mention in passing some other examples of such conclusions that are not related to the EU. The very high rate of growth of the Chinese economy may be an important factor why disparities have not been a major problem yet. Acceleration of economic growth in the USA in 1990s was very important in fighting poverty (Blank, 2000). On the subjective side also the 'tunnel effect' (Hirschman, 1973) is consistent with the hypotheses developed here.

countries, Spain, Portugal and Greece for the period 1973-1998 for GDP per capita as compared to France, based on data by Maddison (2001), are different in the two dimensions: in the static dimension the disparity decreased, while the disparity increased with respect to the time distance dimension. How can the conventional analysis of convergence e.g. reconcile the facts that between 1973 and 1998 Spain and Portugal decreased the percentage difference for GDP per capita with France, while in 1998 the time distance with France increased to 21 years for Spain and 25 years for Portugal, from the respective values of 10 years and 13 years in 1973?

Table 8. GDP per capita, different conclusions about convergence based on static relative disparity and time distance, periods of high growth rate before 1973 and slower growth rate after 1973

	Time distance from France				Percentage difference from France			
	USA	Spain	Portugal	Greece	USA	Spain	Portugal	Greece
1966	-16	15	22	18	45	-43	-52	-50
1973	-8	10	13	13	27	-33	-44	-42
1998	-14	21	25	29	40	-27	-34	-42

Source: Own calculation based on data from Maddison (2001), for Portugal and Greece 1968 instead of 1966.

For the observed developments until 1973 the qualitative conclusions about the convergence based on static relative disparity and time distance are similar, both time distances and percentage differences from France were decreasing. This means that all four cases would belong to field 9 in Table 7. The change from 1973 to 1998 is a different story. USA again improved its position in GDP per capita with France in both dimensions; the percentage difference was now 40 percent and time lead 14 years. The qualitative conclusion about convergence or divergence was the same in both dimensions; the case belongs to field 1. However, for the three compared EU countries the conclusions about convergence or divergence are qualitatively different for the static dimension and the time dimension of disparity. Spain and Portugal further decreased the percentage difference with France, while for Greece the percentage difference remained unchanged. The change in time distance shows a very different picture: in the period 1973- 1998 the time distance with France increased for Spain from 10 to 21 years, for Portugal from 13 to 25 years, and for Greece from 13 to 29 years. This is not a result of a situation that GDP per capita for these three countries would be growing slower than that of France. On the contrary Spain and Portugal were growing faster, otherwise the percentage differences would not be decreasing. The cases of Spain and Portugal belong to field 7 and the case of Greece in field 4 of Table 7. As explained at the beginning of this section about the growth rate effect, the increase of time distances for these three countries in comparison to France in the last 25 years is the consequence of the fact that the absolute value of growth rate of GDP per capita was in the period 1973-1998 lower than in the period before 1973. In a dynamic framework where both differences between growth rates and absolute magnitude of the growth rates are taken into account, a broader concept of the convergence might deliver important new conclusions, which cannot be reached without this broader theoretical and analytical framework.

6. Conclusions

Time distance concept and S-distance statistical measure are theoretically universal, intuitively understandable and immanently practical as a new view of the information content that has always existed in the time series data and related issues. Though time and money are two most common units of measurement used to assess and to compare various situations, the time distance approach and S-distance measure have not been taken into account by the present state-of-the-art of comparative analysis.

As time distance is a generic concept, it is not a methodology oriented towards some specific substantive problem, it presents an additional view to many problems and applications. In its role as a descriptive statistical measure, complementing existing approaches, time distance can be applied literally to thousands of cases of time series comparisons so that additional information content embodied in countless databases in different fields of concern for socio-economic research is not left unutilised.

Time-distance as a statistical measure has two important advantages. One big advantage is that it is defined in standardized units - time - which means that everybody understands the notion of the time lead or time lag between two compared units for a given level of the indicator. This makes it not only a transparent analytical measure but also an excellent presentation and communication device, which is of great importance for its practical use and of considerable influence on public opinion. The second big advantage of this approach is that the results and conclusions based on the two-dimensional comparative analysis add new information and new insight, while none of the earlier results are lost or replaced.

In addition to the use of S-distance as a descriptive statistical measure, the broader conceptual framework poses new interesting questions for growth and welfare theory, and the related policy issues, not discussed in this paper. An important hypothesis about the interrelationship between efficiency, growth and disparity can be formulated. In the conventional theory the trade-off between growth and inequality is emphasised. In this framework a high growth rate (with appropriate distribution policy) is not only a means for reaching higher levels of satisfaction of needs faster, but can also be a means of reducing disparities, at least in the time dimension. Lower growth rates should signal to politicians that an increase in the degree of disparity may be felt and that social tension may be increasing and cohesion decreasing (Sicherl, 1992). If one does not use explicitly the broader framework outlined here, there is a possibility that in political debate and policy formulation various interest groups would intentionally look only at the specific statistical measure that will suit their particular interest.

The methodology presented combines the conventional predominantly static approach to comparisons of disparities in economic and social indicators with the novel concept of time distance and the associated statistical measure S-distance. This will permit perceiving and measuring disparities also in time and an integration of static and intertemporal comparisons to deliver better understanding of the situation to researchers, policy makers, media and the general public.

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