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Socio-economic Indicators Center
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THINK AND COMPARE ALSO IN A NEW DIMENSION: S-TIME-DISTANCE

BENCHMARKING AND MONITORING IN THE TIME DIMENSION: EXAMPLE FOR INFANT MORTALITY RATE FOR MANY COUNTRIES AND FOR WORLD REGIONS

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INTRODUCTION

This paper is predominantly methodological. It should serve the purpose to illustrate by a simple example of some results for a selected indicator (infant mortality rate) **how the time distance approach can in general contribute a new complementary understanding to the indicator analysis across many years, many indicators and many fields of concern.**

The perceptions on well-being and societal progress and the resulting decisions, behaviour and actions undertaken are also influenced by the quantitative **indicators and measures that are used in the measurement, presentation and semantics of discussing these issues.** They are indispensable elements from which the perceptions are formed and the decisions are being made. The present state-of-the-art is not fully exploiting the information content available in existing data with respect to certain elements of the time dimensions involved.

In empirical research the art of handling and understanding of different views of data is crucial for discovering the relevant patterns. Time distance in general means the difference in time when two events occurred. We define a **special category of time distance** related to the level of the analysed variable (e.g. Sicherl 1973, 2004a, 2004b, 2007a, for details see Annex). The **statistical measure S-time-distance** measures the distance (proximity) in time between the points in time when the two series compared reach a specified level of the variable X.

Since events are dated in time, in **time series comparisons**, regressions, models, forecasting and monitoring, the notion of time distance always existed as a "hidden" dimension. Time, besides money, is one of the most important reference frameworks in a modern society. The main proposition is that people have memories of the past and expectations about the future; they **compare over many dimensions and over time**.

Empirically, the perceptions of the degree of disparity may be very different in static terms and in time distance. **This innovation opens the possibility for simultaneous two-dimensional comparisons of time series data** in two specified dimensions: **vertically (standard measures of static difference) as well as horizontally (Sicherl time distance)**, providing a new dimension of analysis to a variety of problems. As different statistical measures may lead to different perceptions about the situation **the broader conceptual and analytical framework leads to new conclusions and semantics important for policy considerations.**

The results and conclusions based on the two-dimensional analysis add a new dimension and new insights for benchmarking, gap analysis, monitoring targets, plans, budgets, projections and scenarios, while none of the earlier results are lost or replaced. The intention is to **complement rather than replace** the conventional static measures of disparity and provide the two-dimensional measurement of the gap as input into an assessment of a broader dynamic notion of the overall degree of disparity. **Gap timing enables additional exploitation of data and visualization for time related databases and indicator systems. A new set of information with clear interpretability**, hidden in the available data, is now provided for policy use over a very large domain of issues due to **an added dimension of measurement and analysis.**

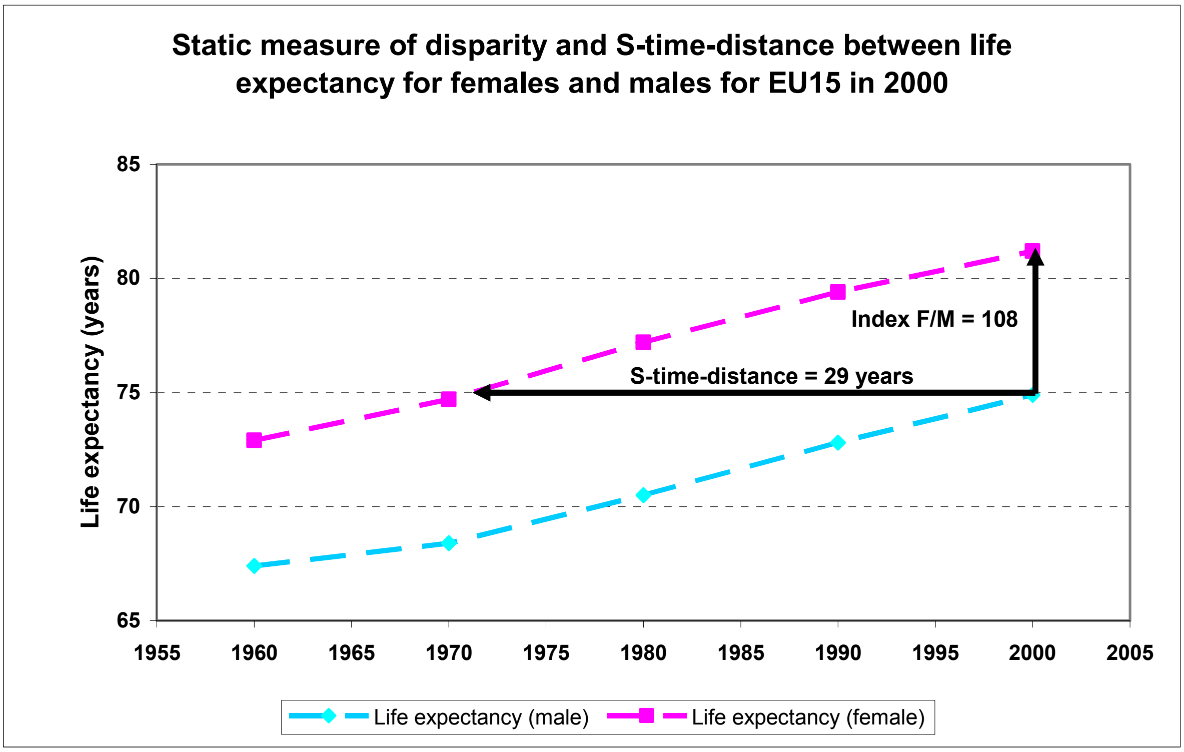
This paper concentrates only on a brief overview of an example of using the time distance measure for benchmarking, monitoring of implementation of MDGs and velocity measurement for a selected development indicator and deals neither with the desired combination with the static measures of the gap nor with the substantive analysis.

1. BENCHMARKING WITH S-TIME-DISTANCE

As a simple example of comparing two units over time and indicator space for two different indicators we can employ the figures below presenting trends for gender life expectancy and for digital divide for selected age groups in the EU15. In graphical terms, the usual way is to compare the time series in the **vertical dimension**, i.e. for a given point in time. The time distance approach uses an additional perspective; it compares the respective time series in the **horizontal dimension**, i.e. for a given level of the variable. The application for the evaluation of the magnitude of the gap in benchmarking analysis in the two dimensions in the figure below is self-explanatory. For these two cases **the theoretical hypothesis that the perception of the degree of disparity in time may be very different from that in static terms, is confirmed** both for each of the indicators separately and across the two indicators.

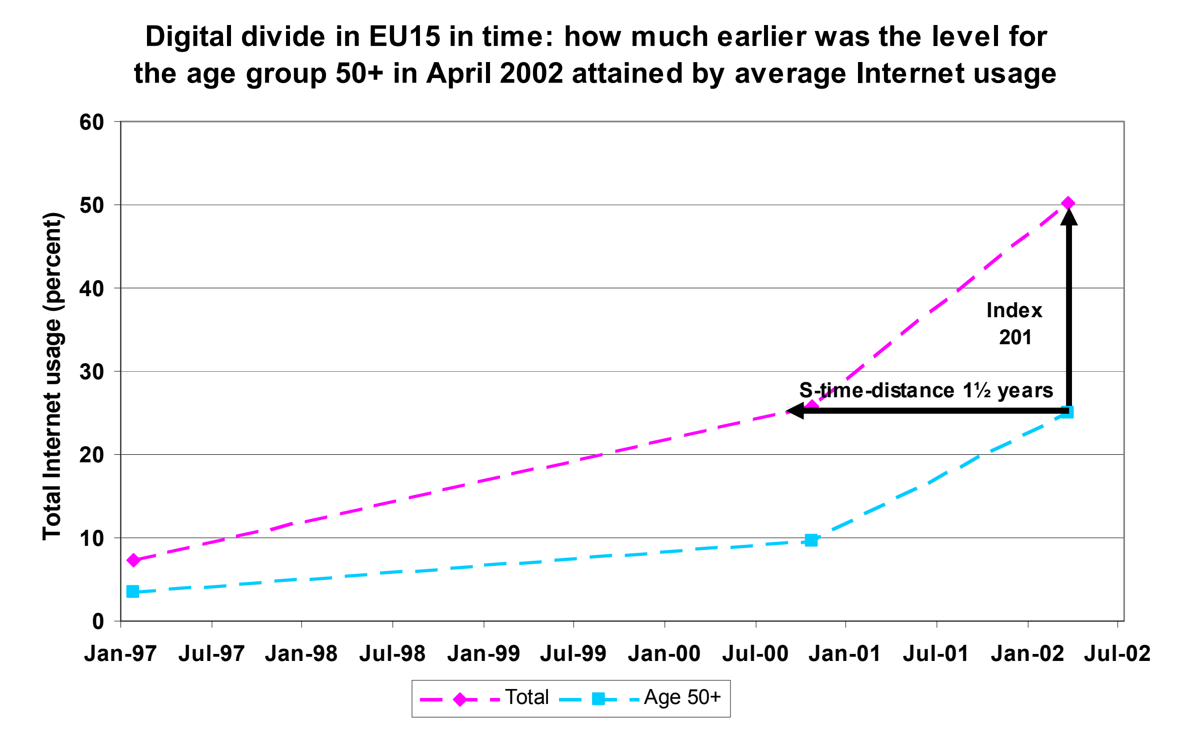
A drastic example of this can be found in contrasting the evaluation of the gap in the two dimensions for two indicators: for the EU15 gender differences in life expectancy, as an important but slow growing indicator, and for the Internet usage for the age group 50+ behind that of total population, as an example of very fast growing indicator.

In the EU15 in 2000 the female life expectancy was 6.3 years higher, which amounted to about 8 percent difference in relation to that of men[1]. However, the time distance was an astonishing 29 years. This means that women attained the value of the male life expectancy for 2000 already in 1971, about three decades ago. The perception whether the gender difference in life expectancy in the EU15 is large or small depends on the measure used: static percentage difference is only 8 percent, while S-time-distance amounts to 29 years.



[1] Own calculations based on data by Eurostat.

With respect to the percent of Internet usage in April 2002, the value for total population was 50.27 percent, while that for the age group 50+ amounted to 25.05 percent[2]. The former category had a 100 percent higher value, or the latter attained only 50 percent of the former. But the time distance was only about 1.6 years (19 months), due to very high growth rates of Internet usage. The perception whether the digital divide (age group 50+ with average Internet usage) in the EU15 is large or small depends on the measure used: while static percentage difference of 101 percent is very large, the S-time-distance amounts to only to approximately 1.5 years.



For a more realistic conclusion all measures should be presented simultaneously. This is important for analysis and policy debate for a single indicator and especially for comparisons across different fields of concern.

Without a more complex subjective evaluation of various options there is no unique judgment about societal progress. We can conclude that the addition of S-time-distance measure undoubtedly increases the 'objective' elements on the basis of which people could understand the situation better and form their own perception in line with their preferences. Comparing across many indicators and fields of concern is the essence of quantitative work in forming perceptions about the overall "position" and "progress"[3]. It has been shown that comparing across indicators S-time-distance in many cases produces different and sometimes very surprising new qualitative conclusions.

[2] Own calculations in Sicherl (2003) based on data from the survey in the SIBIS project, the detailed description of the definition of the disadvantaged groups is found in Selhofer and Huesing (2002).

[3] The OECD World Forum project "Statistics, Knowledge and Policy" is a most welcomed initiative to advance and co-ordinate the work in this field on the OECD and world levels. The contribution of the time distance methodology to the inter-temporal aspect of measuring well-being and societal progress is presented in Sicherl (2006a, 2006b, 2007a) and in Sicherl (2007e) as a background paper for the Istanbul World Forum.

This advantage is derived from a broader theoretical framework explained earlier, which additionally exploits some information on the time dimension that is available in existing databases but neglected by the present state-of-the-art. In this framework overall degree of disparity between two units for a given indicator is a weighted combination[4] of static and time distance measures, the perception depending on the subjective weights given to them.

For the case discussed in the footnote about the change in the growth rate between two periods even the direction of the change in the three measures of the gap would be different. However, if one does not use explicitly the broader framework outlined here, there is a possibility that in political debates and policy formulation **various interest groups would intentionally look only at the measure which will suit their particular interest.** Those who would like to argue that disparities increased, would choose absolute static measure, relative static measure would be used to claim that there has been no change, and time distance to show that this aspect of disparity decreased. Obviously, one should take into account all these aspects simultaneously. Such more complex evaluation of the convergence and divergence in the two dimensions is beyond the scope of this paper.

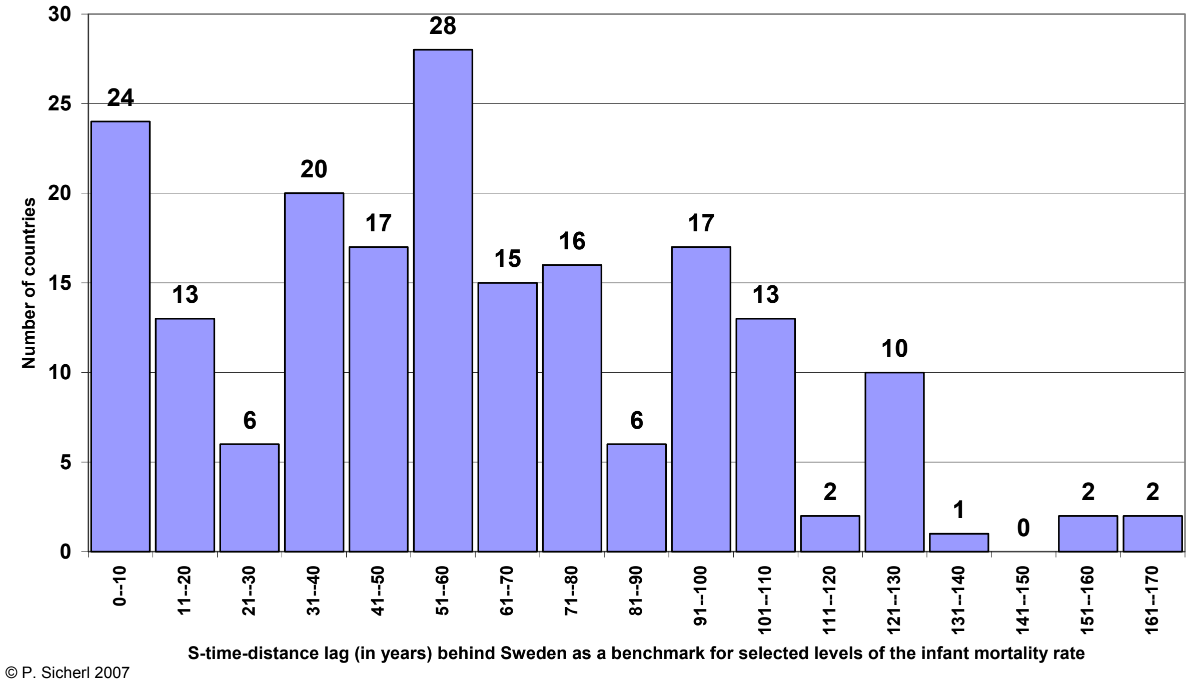
In the benchmarking part of the paper we shall only show the summary result of benchmarking the 2005 values for 192 countries against Sweden as a benchmark. The procedure is as follows. The trend for Sweden as a benchmark is approximated from the long term data by Mitchell (2003) for infant mortality rate for the period starting in 1751. To diminish the yearly variations we calculated for Sweden 3-years moving averages. The 2005 values of infant mortality indicator for 192 countries are taken from the web page of UNICEF (2007); then for each country it is evaluated in which year its 2005 value was attained in Sweden in the past. Subtracting this historical information from 2005 gives the S-time-distance estimate of the time lag behind Sweden for the current level of the respective country.

This gives us 192 estimates of S-time-distance for the current levels for the analysed countries. There is no room to display the detailed results here except to show a summary perception of the situation in the time dimension. The frequency distribution of these S-time-distances shows wide and uneven dispersion of the time gap. According to UNICEF data there is a group of 24 countries in the first frequency range for which their current levels do not differ from the trend for Sweden for more than 10 years. Then there are three high frequency classes for the range of S-time-distances between 31 and 60 years. The median is at about 57 years, which means that about one half of the countries show larger time lag.

This is now a brief new picture of the situation for infant mortality in the world if we are using gap timing procedure for benchmarking against historical development. Obviously this is only the first descriptive illustrative step that has to be further extended with more detailed substantive qualitative and quantitative analyses at the regional, country and sub-national levels, also in combination with other material, policy, social, financial and institutional issues. There are several obvious extensions possible:

[4] The value judgment that people attach to the time dimension of disparities and to the static dimension of disparity is an open question for interdisciplinary research. However, it may be safe to assume that a situation with 50 per cent static difference and time distance of 10 years is preferable to the situation with the same static difference and time distance of 40 years as indicated in an example what would happen to the degree of disparity in the case when the rate of growth of an indicator increases from one period to another, but is for simplicity reasons the same for the two compared units (e.g. from 1 per cent to 4 per cent) and the static measure of the gap would be 50 percent in both cases. The conventional analysis based on only ratios, percentage differences, Gini coefficients or Theil indexes alone does not distinguish such situations as different degrees of disparity (Sicherl, 2006d, 2007a).

Frequency distribution of time lag of 192 countries behind Sweden for 2005 for infant mortality rate (for S-time-distance in years)



- These values to be combined with the static absolute and relative measures of the gap in the infant mortality rate at the national and sub-national levels
- The frequency distribution of countries by S-time-distance could be analysed by combining it with distribution by other characteristics like world regions, level of development, other variables, other measures of the gap for the same indicator or for other indicators, etc.
- Trends in S-time-distance over time can be estimated depending on the availability of data for various indicators. For infant mortality rate the example of trends by regions based on UNICEF data is indicated in Section 3: Comparing Regions and Velocity of Improvement; this can be done also for countries as well as other units.
- In technical terms gap-timing is an independent concept, the values of S-time-distance depend only on levels of the variable and time.
- A very interesting application is comparing S-time-distances across a number of indicators. A study for EUROCHAMBRES confirmed that S-time-distance is not only a novel generic statistical measure but also an excellent presentation and communication tool for policy use and that it can influence public opinion[5].
- The values of S-time-distances can be further processed with the standard statistical and mathematical procedures to verify various hypotheses. In graphical terms they can be presented in various ways; some of them have been presented here. It would be of interest to combine the gap timing also with data presentation in the Gapminder tool.

- [5] In the study for EUROCHAMBRES (Sicherl, 2007b) the results for benchmarking of the EU on the world scale and for monitoring the implementation of the Lisbon strategy showed that social partners (e.g. business associations) can use the new time distance perspective for policy debate at international and national levels. It was reported in Financial Times and in many media around the world.

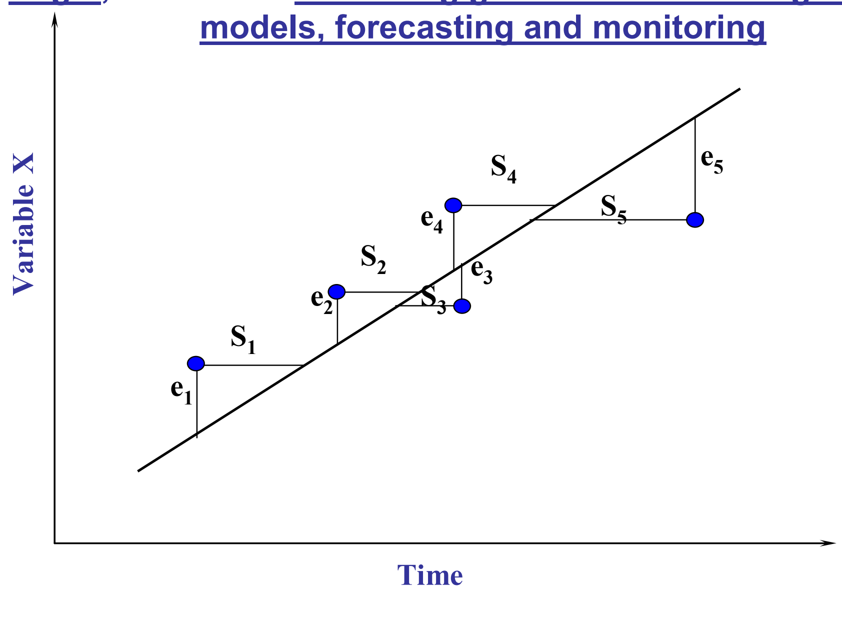
2. MONITORING IMPLEMENTATION OF MILLENNIUM DEVELOPMENT GOALS IN THE TIME DIMENSION

This section on the application to the monitoring of implementation of the MDGs in the time dimension is in data and computational terms much less demanding than the application to benchmarking and it is immediately operational.

It stems from the more general idea of comparing actual and estimated values and thus by deriving deviation between them in the two dimensions. In the Annex we refer also to the extensions to measuring deviations between estimated and actual values in regressions and models, in forecasting, for error in timing and causality. For monitoring MDGs the application is much simpler than for those possible applications in econometrics. Let us assume that the line in the figure below is the line to target from 1990 to 2015 for a given indicator and country (the line to target need not be linear; this is done here for the sake of the simplicity of presentation only). The dots represent the actual values in a given year and the deviation from the corresponding line to target can be measured in the two dimensions discussed.

The generic idea for many other applications of S-time-distance

S-time-distance adds a second dimension to comparing actual value with estimated value, forecast, budget, plan, target, etc. and to evaluating goodness-of-fit in regressions, models, forecasting and monitoring



Targets are usually expressed not only in terms of the indicator values but simultaneously also in time. As processes towards their implementation are related to time, it is very natural and useful to describe e.g. the degree of implementation in two dimensions: 1 per cent below the path to target at a given point in time, and 2 months behind the path to target in terms of the achieved level at that point in time. In other words, the target line (estimate) is 1 per cent higher and 2 months early when compared with the actual implementation.

There are alternative ways of expressing these matters, but it is obvious that the interpretation of how to overcome the time delay may be a very relevant additional practical procedure to be routinely applied to a large number of physical and financial indicators before turning to the more complicated programs. The interpretation of the deviation from the line to target with S-time-distance measure is straightforward and intuitively understandable. It is like tracking the actual arrivals in comparison with the train or bus timetable, the only difference is that the geographical space is in our application replaced with the indicator space.

It is especially useful in the cases where the targets are clearly established and/or the monitoring is already a legal or administrative requirement. This can be a standard procedure in numerous other activities of the UN and other international agencies and of the national and local institutions like monitoring and evaluation of implementation of development plans and policy targets, as well as for the relevant budgets, aid disbursements and projects. **The time distance information seems to be at least as helpful in providing a proper perception of the progress in implementation or the lack of it as the percentage difference.**

My background paper for the OECD/ISTAT Seminar on Dynamic Graphics to Present Statistics in Rome, as one of the preparatory events before the Istanbul OECD World Forum, provides a more detailed evaluation of the implementation of MDGs in the time dimension for 9 selected indicators for the UN defined world regions, for Developing Regions total and for China, as an example of application to country level across more indicators (Sicherl, 2007c). The results and conclusions will not be repeated here, except for showing the table for infant mortality rate for 113 countries as an example of results for 2004 across many countries. A similar study was prepared on monitoring implementation of the Lisbon Strategy and National Reform Programmes in the European Union (Sicherl, 2006c, 2007d).

Infant mortality rate was chosen for this example of a MDG indicator for two reasons. Firstly, it is an important indicator for Goal 4: reducing child mortality. Secondly, the estimates in the UN Millennium Development Goal Indicator Database for infant mortality rate provide estimates for 1990 and 2004 for over 130 countries. When the value of S-time-distance in the table below is negative, this means that the actual progress is ahead of the assumed progress indicated on the linear path to target. In other words, the actual implementation was better than required by the calculated average path to target. For instance, the value of infant mortality rate for Singapore was 7 in 1990; the implied target for 2015 is 2.3. In 2004 the actual value was 3; this value was on the path to target foreseen to be achieved in 2011. Since it was achieved already in 2004, the S-time-distance of -7 years indicates that this progress was attained 7 years earlier (2004-2011) than calculated on the average path to target.

The results presented in Table 1 show that for 46 countries the progress in reducing infant mortality rate in the period 1990-2004 was better than required by the assumed average absolute rate of decrease as calculated by the linear path to target. For the other 67 countries the implementation in 2004 measured by S-time-distance shows smaller or larger delay as compared to the assumed average absolute rate of decrease. However, it should not be taken to imply that many of the countries may not by 2015 achieve their targets. This will depend also on their performance in the next decade.

Table 1. Monitoring implementation of the Millennium Development Goal in the time dimension BY COUNTRIES (results for 113 countries), infant mortality rate, situation in 2004

Country	2004 value	S-time-distance (years)		Country	2004 value	S-time-distance (years)
Egypt	26	**-10.7**		Korea, Republic of	5	**-0.1**
Oman	10	**-8.5**		Malaysia	10	**-0.1**
Peru	24	**-8.5**		Samoa	25	**-0.1**
Bahamas	10	**-7.9**		Bhutan	67	**0.0**
Turkey	28	**-7.8**		Philippines	26	**0.3**
Singapore	3	**-7.4**		Paraguay	21	**0.4**
Syrian Arab Republic	15	**-7.4**		Brazil	32	**0.5**
Maldives	35	**-6.9**		Fiji	16	**0.5**
Viet Nam	17	**-6.7**		Trinidad and Tobago	18	**0.6**
Sri Lanka	12	**-6.2**		Occupied Palestinian Territory	22	**0.8**
Chile	8	**-5.9**		Algeria	35	**0.8**
Timor-Leste	64	**-5.0**		Saint Lucia	13	**0.9**
Cyprus	5	**-4.8**		Mozambique	104	**1.2**
Indonesia	30	**-4.8**		Mauritius	14	**1.5**
Israel	5	**-4.8**		Vanuatu	32	**1.5**
El Salvador	24	**-4.4**		Venezuela	16	**1.5**
Tunisia	21	**-4.3**		China	26	**2.2**
Libyan Arab Jamahiriya	18	**-4.2**		Costa Rica	11	**2.3**
Mongolia	41	**-3.8**		Cook Islands	18	**2.5**
Ecuador	23	**-3.4**		Guinea	101	**2.6**
Dominican Republic	27	**-3.3**		Jordan	23	**2.6**
Lao People's Democratic Rep.	65	**-3.2**		Panama	19	**2.9**
Cuba	6	**-3.1**		Honduras	31	**2.9**
Guatemala	33	**-2.9**		Seychelles	12	**3.0**
Morocco	38	**-2.9**		Barbados	10	**3.3**
Bangladesh	56	**-2.5**		Kuwait	10	**3.3**
Thailand	18	**-1.7**		Haiti	74	**3.7**
United Arab Emirates	7	**-1.6**		Lesotho	61	**3.7**
Nepal	59	**-1.4**		Micronesia, Federated States of	19	**3.9**
Comoros	52	**-1.3**		Madagascar	76	**4.2**
Eritrea	52	**-1.3**		India	62	**4.2**
Iran (Islamic Republic of)	32	**-1.3**		Guyana	48	**4.6**
Nicaragua	31	**-1.1**		Uruguay	15	**4.6**
Bahrain	9	**-1.0**		Malawi	110	**4.8**
Cape Verde	27	**-1.0**		Kiribati	49	**4.8**
Colombia	18	**-1.0**		United Republic of Tanzania	78	**5.2**
Grenada	18	**-1.0**		Tonga	20	**5.4**
Saint Kitts and Nevis	18	**-1.0**		Namibia	47	**5.9**
Saudi Arabia	21	**-1.0**		Palau	22	**6.0**
Bolivia	54	**-0.8**		Niger	152	**6.3**
Argentina	16	**-0.4**		Brunei Darussalam	8	**6.5**
Mexico	23	**-0.2**		Pakistan	80	**6.5**
S-time-distance (years) = Time (actual) – Time (path to target)						
S-time-distance (years) = - time lead (progress better than path to target), + time lag (progress worse than path to target)						

Table 1. continued

Country	2004 value	S-time-distance (years)		Country	2004 value	S-time-distance (years)
Benin	90	**6.9**		Countries for which infant mortality rate was constant or even increasing over time		
Saint Vincent and the Grenadines	18	**7.2**				
Belize	32	**7.3**		Angola	154	
Guinea-Bissau	126	**7.4**		Botswana	84	
Marshall Islands	52	**7.5**		Burundi	114	
Djibouti	101	**7.6**		Cambodia	97	
Myanmar	76	**7.8**		Cameroon	87	
Yemen	82	**7.9**		Central African Republic	115	
Ethiopia	110	**8.0**		Chad	117	
Nigeria	101	**8.1**		Cote d'Ivoire	117	
Lebanon	27	**8.1**		Democratic Rep. of the Congo	129	
Sudan	63	**8.4**		Equatorial Guinea	122	
Qatar	18	**8.6**		Gabon	60	
Suriname	30	**8.6**		Iraq	102	
Burkina Faso	97	**8.7**		Jamaica	17	
Uganda	80	**8.8**		Kenya	79	
Gambia	89	**8.9**		Korea, Dem. People's Rep. of	42	
Mali	121	**8.9**		Liberia	157	
Dominica	13	**9.0**		Rwanda	118	
Senegal	78	**9.0**		Sao Tome and Principe	75	
Togo	78	**9.7**		Somalia	133	
Solomon Islands	34	**10.1**		South Africa	54	
Tuvalu	36	**10.3**		Swaziland	108	
Ghana	68	**10.5**		Zambia	102	
Mauritania	78	**10.9**		Zimbabwe	79	
Papua New Guinea	68	**11.0**				
Sierra Leone	165	**11.9**				
Congo	81	**13.1**				
Afghanistan	165	**13.3**				
S-time-distance (years) = Time (actual) – Time (path to target)						
S-time-distance (years) = - time lead (progress better than path to target), + time lag (progress worse than path to target)						

The most severe problem in implementation is related to the 23 countries at the end of the table which did not show significant reduction in the infant mortality rate between 1990 and 2004. This implies that their time delay is at least 14 years.

Further in depth extensions of monitoring the implementation of the MDGs at various levels could follow similar suggestion as indicated at the end of Section 1 for benchmarking. However, the computational requirements would be simpler. **SICENTER is in the process of developing a web application which would allow a variety of interested users such as international and national organizations, NGOs, students and media to monitor with S-time-distance the lead or lag in time** from the Lisbon and NRP targets in the case of EU and for MDGs or other planned, budget, or aid disbursement targets **at world, regional, national or sub-national levels**.

3. COMPARING REGIONS AND VELOCITY OF IMPROVEMENT

This section is an enhancement of the earlier examples for benchmarking and monitoring for many countries in two ways. Firstly, by using UNICEF (2007) data for infant mortality rate for selected group of countries and regions for several data points in the period 1960-2005 it is possible to illustrate the process of gap timing over a long period of time. Secondly, in addition to the more discussed S-time-distance measure the second new statistical measure S-time-step is used to compare the velocity of improvements in reducing infant mortality rate between two consecutive levels of the indicator. Namely, an interesting analytical and policy question is whether the developing countries are now improving the situation with respect to infant mortality faster than did the now developed countries (using Sweden as the representative case) at the same levels in the past. The definition for both measures is provided in the Annex.

As indicated earlier, the figures and tables are meant to provide a visual guide to the procedure of gap timing without discussing the substantive issues beyond this methodological purpose in this paper. The figure below indicates the possibility of observing the gaps in the two dimensions: static disparity for a given point in time and the gap in time for a given level of the indicator. Static measures of the gaps between different units compared are restricted to the given points in the period 1960-2005 depending on the available data. Both special time distance measures can be calculated for those levels for which data are available for Sweden and the compared units (with interpolation they are available for over 200 years for Sweden).

Table 2 is the empirical example of the respective theoretical **time matrix table** shown in the Annex. Time when a given level of the indicator was achieved is estimated for a selected range of levels of the indicator (in this case infant mortality rate). The time matrix has the characteristics of a table-figure combination; it is possible to quickly observe visually the approximate range of the indicator within which the values for each unit were moving. With Sweden as a benchmark, the corresponding values of **S-time-distance** for a given level of the indicator are obtained if we subtract vertically the estimated time for the respective country from that of Sweden. The estimate of **S-time-step** is obtained by subtracting horizontally for each unit separately the respecting times between two neighbouring levels of the indicators. It measures the time that was needed for the change between the two consecutive levels of the indicator. The shorter the time needed the higher the velocity of movement between the respective levels of the indicator.

The corresponding results for S-time-distance lag behind Sweden for the selected levels of the infant mortality rate are presented in Table 3 for regions and selected groupings and in the figure following it (only for Sweden and for the four major country groupings). Without going into details one can observe that, with the exception of the least developed countries and Latin America and Caribbean, the previous clear trend of diminishing S-time-distances from Sweden for higher levels of the infant mortality has been changing, in the last period this trend started to show signs of stagnation or of reversal at lower levels of the indicator.

One would need more detailed yearly data to verify the significance of these indications. It is also possible that the errors in indicator measurement might be of such magnitude that they can interfere with the possibility of a clearer conclusion, especially for industrialized countries where the static differences are becoming minor. S-time-step as a possible velocity measure

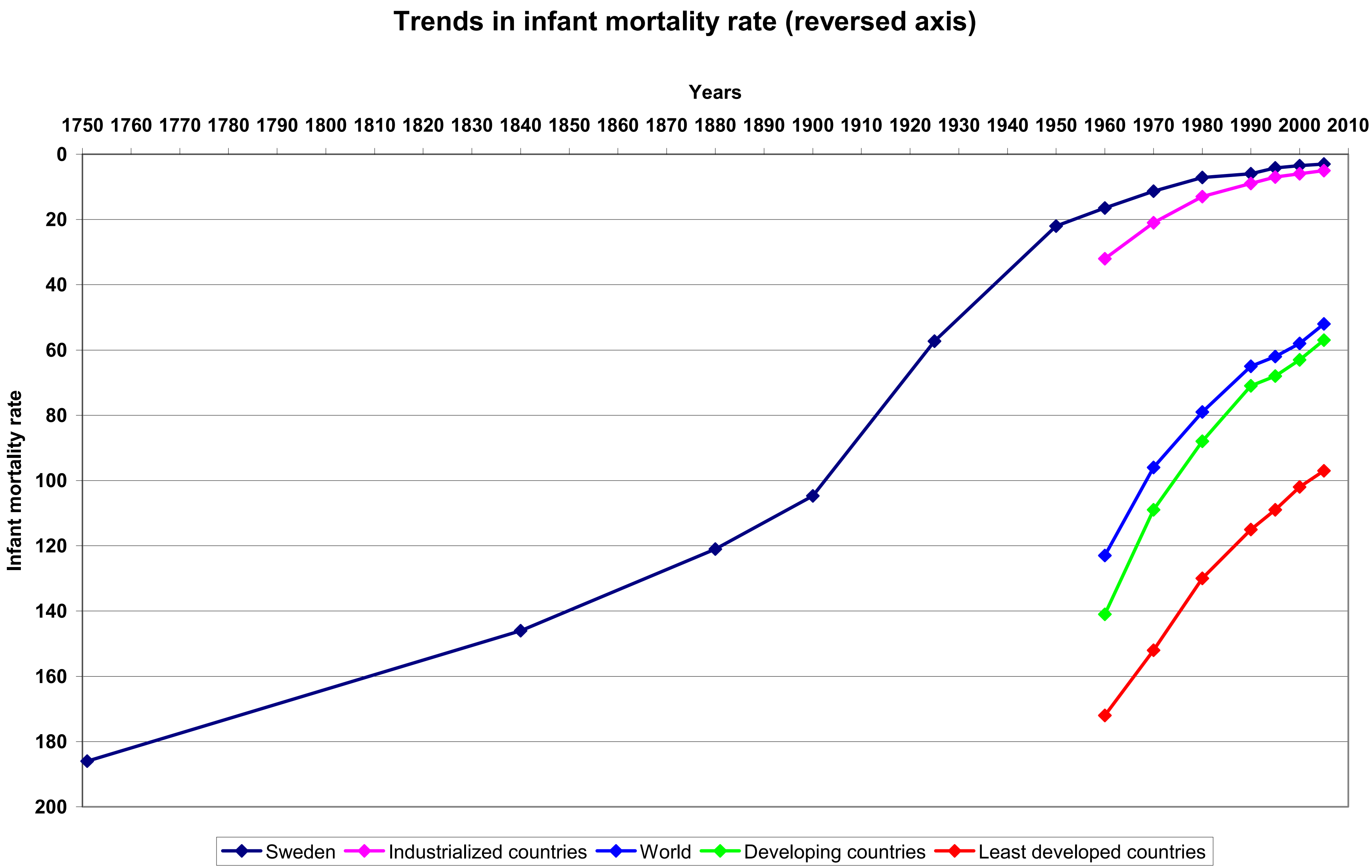

Trends in infant mortality rate (reversed axis)
Years
1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Infant mortality rate
0 20 40 60 80 100 120 140 160 180 200
Sweden
Industrialized countries
World
Developing countries
Least developed countries

Table 2. Time matrix for calculation of S-time-distance and S-time-step

Time when a given level of the infant mortality rate was attained by each unit

Level	5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Sweden	1993	1973	1954	1944	1937	1930	1924	1918	1913	1908	1902	1890	1875	1865	1856	1846	1832	1812	1792
Industrialized countries	2005	1988	1971	1962															
World							1998	1986	1979	1974	1969	1965	1961						
Developing countries							2003	1992	1985	1979	1974	1970	1967	1963	1960				
Least developed countries											2002	1994	1987	1980	1975	1971	1966	1961	
Latin America and Caribbean				2000	1992	1986	1981	1976	1972	1968	1962								
East Asia and Pacific				2003	1994	1984	1978	1975	1971	1969	1967	1965	1963	1961					
Central and East. Europe, CIS				2004	1997	1984	1976	1968											
Middle East and North Africa						1999	1990	1987	1983	1980	1978	1975	1972	1969	1966	1963			
South Asia								2002	1995	1990	1986	1982	1977	1970	1964				
Eastern and Southern Africa											1997	1983	1977	1973	1968	1963			
Sub-Saharan Africa												1995	1980	1976	1972	1968	1963		
Western and Central Africa												2003	1989	1979	1975	1970	1966	1962	

Source: Own calculations based on UNICEF data for period 1960-2005, long term series for Sweden from B.R. Mitchell, International historical statistics, Europe 1750-2000, Fifth Edition, Palgrave, MacMillan, New York

Table 3. S-time-distance lag (in years) behind Sweden as a benchmark for selected levels of the infant mortality rate

(- ahead in time, + behind in time: -time lead, + time lag against Sweden)

Level	5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrialized countries	12	14	18	17															
World							74	68	66	66	66	75	86						
Developing countries							79	73	72	71	72	80	91	98	105				
Least developed countries											100	104	112	115	120	125	134	149	
Latin America and Caribbean				56	55	56	57	58	59	60	59								
East Asia and Pacific				58	57	54	55	57	58	61	64	75	88	96					
Central and East. Europe, CIS				60	59	54	53	49											
Middle East and North Africa						69	66	68	70	73	75	85	97	104	110	117			
South Asia								83	81	82	83	92	102	105	109				
Eastern and Southern Africa											95	93	102	107	112	117			
Sub-Saharan Africa												105	105	111	116	122	131		
Western and Central Africa												113	114	114	119	124	134	150	

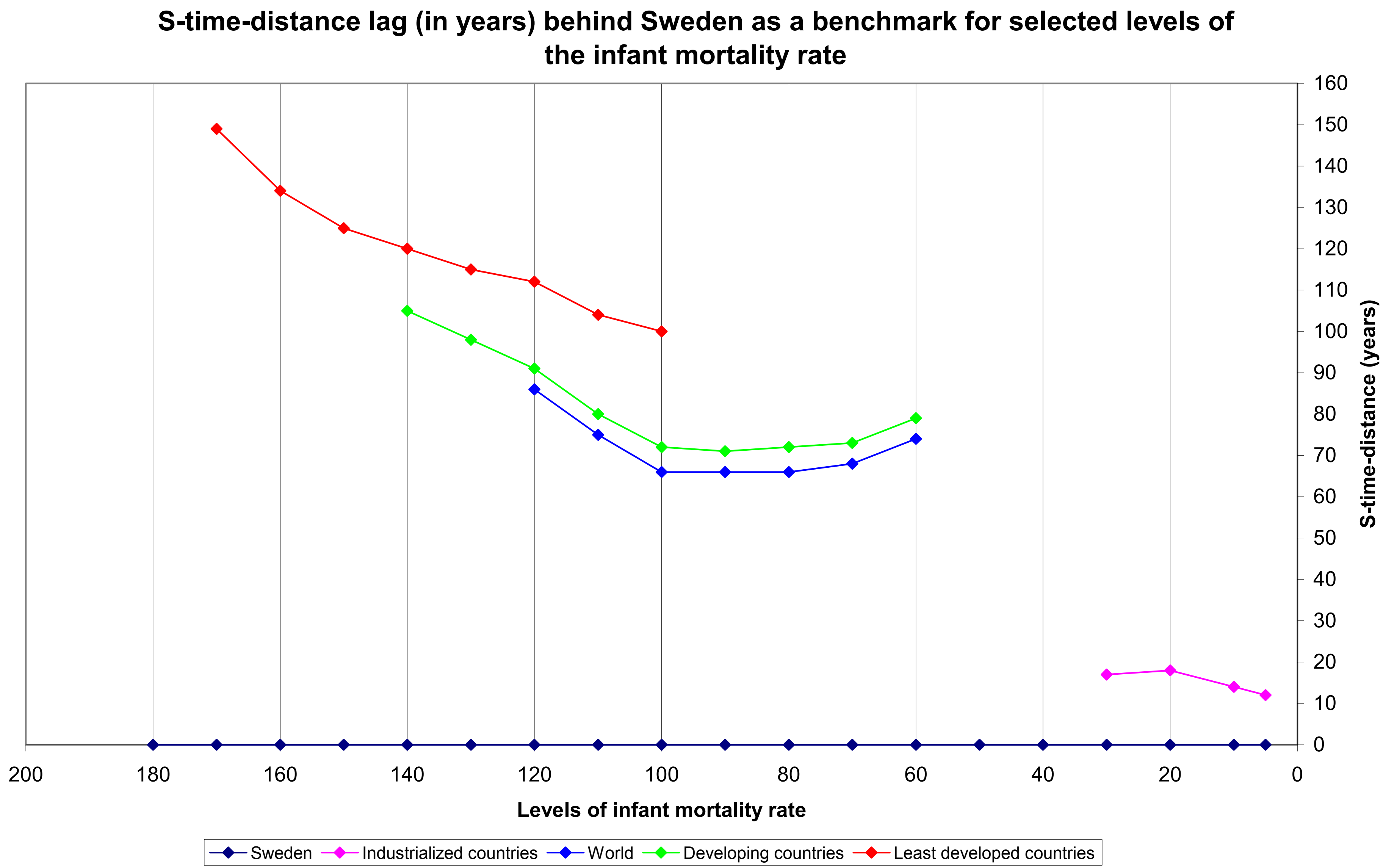
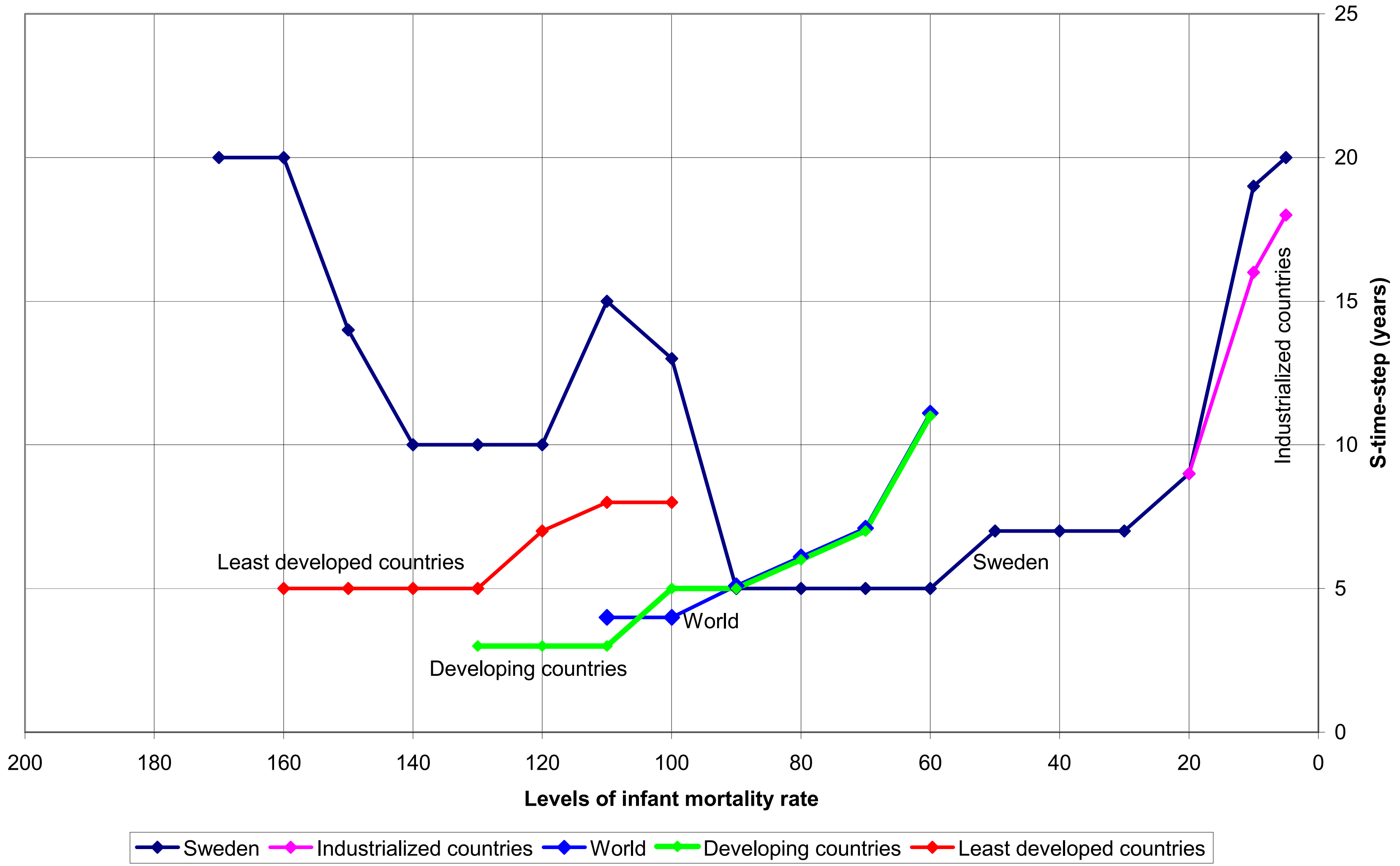

S-time-distance lag (in years) behind Sweden as a benchmark for selected levels of the infant mortality rate
S-time-distance (years)
Levels of infant mortality rate
Sweden
Industrialized countries
World
Developing countries
Least developed countries

Table 4. S-time-step in years

Time elapsed between two consecutive levels of the infant mortality rate

Level	5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Sweden	20	19	9	7	7	7	5	5	5	5	13	15	10	10	10	14	20	20	
Industrialized countries	18	16	9																
World							11	7	6	5	4	4							
Developing countries							11	7	6	5	5	3	3	3					
Least developed countries											8	8	7	5	5	5	5		
Latin America and Caribbean				8	6	6	4	4	5	6									
East Asia and Pacific				9	10	6	3	3	3	2	2	2	2						
Central and East. Europe, CIS				8	13	8	8												
Middle East and North Africa						9	3	3	3	3	3	3	3	3	3				
South Asia								7	5	4	4	5	7	6					
Eastern and Southern Africa											15	6	4	5	5				
Sub-Saharan Africa												15	4	4	4	5			
Western and Central Africa												14	10	4	4	4	4		

S-time-step (in years) for selected levels of the infant mortality rate: How many years were needed to decrease the infant mortality rate between two consecutive levels



of improvements at given levels of the indicator could show further information for this debate.

Table 4 and the figure following it show the situation expressed by S-time-step measure. The predominantly U-shaped curve for Sweden for a period of about two hundred years can lead to an interesting initial hypothesis. In the period before 1902, i.e. before reaching the level of the indicator of 100 Sweden needed a period between 10 and 20 years to achieve a decrease of infant mortality rate of 10 points. The question arises as to whether these results were influenced by low level of knowledge and technology, by specific situation in the country at that time, by the low level of development, or by a combination of such factors. Such analysis in different countries would be helpful also for setting future targets for development goals.

Between the levels of the infant mortality rate from 100 to 30 Sweden needed only 6-7 years to decrease the infant mortality rate by 10 points. The increase in S-time-step after that level is easy to explain. One should expect such development as the value of the indicator approaches slowly in an asymptotic way the best possible value. The corresponding percentage decrease is also much higher for a given absolute magnitude of the step. The same is expected to be found for a more detailed analysis in the group of industrialized countries.

These methodological examples can help us to broaden the analytical and policy perspective, asking new questions and learning from the other's experience. In a similar way detailed examination of the situation for specific grouping, for individual countries, regions, gender or socio-economic groups could be undertaken for a number of indicators in a variety of fields of concern.

4. CONCLUSIONS

Specific conclusions based on empirical examples

1. Benchmarking in the time dimension

- The theoretical hypothesis that **the perception of the degree of disparity in time may be very different from that in static terms** was confirmed by several examples. For a more realistic conclusion **both static measures and S-time-distance should be presented simultaneously**. This is important for analysis and policy debate for a single indicator and especially for comparisons across indicators and/or different fields of concern.
- If not, there is a possibility that in political debates and policy formulation **various interest groups would intentionally look only at the measure which will suit their particular interest.**
- A long-term summary result of benchmarking the 2005 values of infant mortality rate for 192 countries against long-term trend for Sweden as a benchmark **showed the possibility of using gap timing procedure for benchmarking against historical development.** The median S-time-distance behind Sweden is at about 57 years, which means that about one half of the analysed countries exhibit a larger time lag.

2. Monitoring implementation of the MDG in the time dimension

- **The interpretation of the deviation from the line to target with S-time-distance measure is straightforward and intuitively understandable**. It is like tracking the

actual arrivals in comparison with the train or bus time-table, the conceptual difference being that the geographical space is in our application replaced with the indicator space.

- **The results for infant mortality rate for 113 countries for 2004** is presented as an example of results across many countries. For 46 countries the progress in reducing infant mortality rate in the period 1990-2004 was better than required by the assumed path to target calculated by the average absolute rate of decrease over the period 1990-2015. For the other 67 countries the implementation in 2004 measured by S-time-distance shows smaller or larger delay.
- An earlier study on MDGs was done for 9 selected indicators for the UN defined world regions, for Developing Regions total and for China (as an example of application on country level across more indicators). A similar study was prepared on monitoring implementation of the Lisbon Strategy and National Reform Programmes in the European Union. **All these examples show that the S-time-distance information seems to be at least as helpful in providing a proper perception of the progress in the implementation or the lack of it as the percentage difference.**

3. Comparing world regions and velocity of improvement in infant mortality

- When comparing UNICEF (2007) data for infant mortality rate for selected group of countries and regions for several data points in the period 1960-2005 against the historical path for Sweden, it was possible to illustrate the process of gap timing over a long period of time and thus to support the historical perspective in policy analysis.
- The second new statistical measure **S-time-step is used to compare the velocity of improvements in reducing infant mortality rate between two consecutive levels of the indicator.**
- Earlier for higher levels of the infant mortality rate there was a clear trend that S-time-distances behind Sweden were diminishing and that the S-time-step was shorter for developing countries than for Sweden. In the last period, with the exception of the least developed countries and Latin America and Caribbean, **the trend of decreasing S-time-distances started to show signs of stagnation or of reversal at lower levels of the indicator**. This requires more detailed further examination.

General conclusions on measuring gaps in time

1. The time distance approach is useful in two domains: it offers a new view of data that is exceptionally easy to understand and communicate, and it may allow for developing and exploring new hypotheses and perspectives that cannot be adequately dealt without the new concept. **The novel time distance methodology provides a new insight to many problems, additional generic statistical measures, and a presentation tool for policy analysis and debate expressed in time units, readily understood by policy makers, managers, media and general public**.

2. The present state-of-the-art neglects this additional information available in existing time series databases, which leads to information loss that has no justification. In the information age this new view of the existing databases should be evaluated as an **important contribution to a more efficient utilisation of the available information**.

3. **The time distance concept is intuitively understandable and practical**. As it is true for any concept and tool, it is the user who makes the final decision about which tool is appropriate for his/her task or not, but the field of attaining benefits from application of S-time-distance and S-time-step is wide open for imaginative users. It is not a methodology that is oriented only towards some specific substantive problem, but **it represents an additional view to many problems and applications.**

4. In technical terms, in the analysis of time series **the idea of time distance is a generic concept like static difference and the growth rate over time**. What was needed was to combine them into a broader conceptual and empirical operational framework. This is very helpful also for analyzing the quality and consistency of statistical data and indicators over time. One of the advantages of S-time-distance as a statistical measure is its simplicity. Even as a descriptive statistical measure it has many desirable properties: it is expressed in standardized time units, which makes it **comparable across variables, fields of concern and units of comparison.** This is very useful for a statistical measure as there is no need for standardization procedures with respect to these characteristics. In policy terms it is even more important that time units are easily understandable by policy makers as well as laymen, which makes the S-time-distance **an excellent easily understood presentation and communication tool for policy debate and decision making**.

5. **In practical applications it is important to distinguish between backward looking (*ex post*) and forward looking (*ex ante*) time distances**. They relate to different periods, past and future. Backward looking time distance belongs to the domain of statistical measures based on known facts, and there is no need to relate it to any static measure or growth rate. In this paper we have been dealing with the ex post time distance. The second, the forward looking time distance, is important for describing the time distance outcomes of alternative assumptions about future developments or of alternative policy scenarios for the future.

6. To summarize, a substantial effort by the international and national organisations has been and will be channelled into collecting the necessary data for the related system of indicators. Yet we also need concepts and tools of analysis that systematise and transform information into perceptions relevant to different levels of decision makers and interest groups for describing the situations, challenges and scenarios, for proactive discussion and presentation of policy alternatives to policy makers, media, the general public and mobilizing those participating in or being affected by the programs. **Time distance measure is one of such measures with clear interpretability that can be helpful in delivering a broader concept to look at data for a better understanding of the situations and for improved semantics in communication.**

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Annex:
S-TIME-DISTANCE AS A SPECIAL CATEGORY OF TIME DISTANCE[6]

The present state-of-the-art does not realise that, in addition to static comparison, there exists in principle a theoretically equally universal measure of difference (distance) in time when a given level of the variable is attained by the two compared time series. In graphical terms, the usual way is to compare the time series in the **vertical dimension**, i.e. for a given point in time. The time distance approach uses an additional perspective; it compares the respective time series in the **horizontal dimension**, i.e. for a given level of the variable (see e.g. Sicherl, 1973, 2004a).

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 analyzed variable. The suggested statistical measure **S-time-distance** measures the distance (proximity) in time between the points in time when the two series compared reach a specified level of the variable X. The observed distance in time (the number of years, quarters, months, 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.

In the analysis of time series the idea of time distance is a generic concept like static difference and the growth rate over time. Time has until now been used in comparisons mainly as location information, i.e. as a coordinate in a parameter frame forming a coordinate system that is used to organize (or index) a set of variables. In other words, it has played the role of a descriptor, subscript or identifier. The new approach offers new avenues for detecting additional information content, without replacing the existing views. If we choose to interchange in the database the roles of the level of the variable and time, a given level of the variable becomes a descriptor or identifier and time becomes a numeraire in which certain distances between the compared units and time series can be expressed and measured.

The comparison of two points in a time series database entails three elements of information: (i) the respective level of the variable, (ii) to which unit it belongs, and (iii) at what time it happened. There are two obvious generic directions of comparison: by time and by level.

The generic nature of S-time-distance can be shown also by specifying operators that can be applied to a time series database. For two units (i) and (j) we can express such database as implicit functions

$$F_i(X, t) = 0 \text{ and } F_j(X, t) = 0. \quad (1)$$

The present state-of-the-art solves these functions by one of the arguments as

$$X = X_i(t) \text{ and } X = X_j(t) \quad (2)$$

[6] This section is based on Sicherl (2004b), available on www.iariw.org. The shorter versions are available also in Sicherl (2006d and 2007a).

and arrives at static distance like $\Delta X_{ij}(t) = X_i(t) - X_j(t)$. However, it misses the point that additional theoretically universal and practically relevant measures can be obtained by solving them by the other argument using the inverse relations

$$t = t_i (X) \text{ and } t = t_j (X). \quad (3)$$

The result is a time matrix with new information from which new generic measures can be derived.

Annex Table 1. Time matrix from the inverse relations: time when a specified level of the variable was achieved in each compared unit

Level	Time $t_i (X_L)$	Time $t_j (X_L)$
X_{L1}		$t_j (X_{L1})$
X_{L2}	$t_i (X_{L2})$	$t_j (X_{L2})$
X_{L3}	$t_i (X_{L3})$	$t_j (X_{L3})$
…	…	…
X_{Ln}	$t_i (X_{Ln})$	

Two operators applied to the above time matrix lead to the derivation of two novel statistical measures, expressed in standardized units of time that everybody understands. The first suggested statistical measure **S-time-distance** measures the distance (proximity) in time between the points in time when the two compared series reach a specified level of the variable X. It compares two series by subtracting **horizontally** the respective times for a given level in the time matrix.

S-time-distance for a given level of X_L is defined as

$$S_{ij}(X_L) = \Delta t(X_L) = t_i(X_L) - t_j(X_L) \quad (4)$$

where

$$X_i(t_i(X_L)) = X_L \text{ and } X_j(t_j(X_L)) = X_L. \quad (5)$$

[7]

The sign of the time distance comparing two units is important for distinguishing whether we are dealing with time lead (-) or time lag (+) (in a statistical sense and not as a functional relationship)

$$S_{ij}(X_L) = -S_{ji}(X_L) . \quad (6)$$

S-time-distance is calculated from the original values of the variable (with some possible interpolation and extrapolation) without referring to any other information than the levels of the variable and time subscripts. This is a confirmation of the statement that time distance provides an additional (n+1) dimension of the description of the state of a multidimensional space of n variables (X_i, i=1, ….n).

[7] For details see Sicherl (2002), also on possible multiple time intersections.

Subtracting the respective times in the time matrix for consecutive levels of the variable for each column **vertically** derives the second suggested measure **S-time-step**. These vertical differences can be labelled as time steps and represent an alternative description to the growth rate measure. The concept of S-time-step measures the growth characteristics of a series, using the inverse relation to the conventional $\Delta X/\Delta t$ or growth rate metrics. S-time-step as a measure expressed in units of time is defined as

$$S_i(\Delta X_L) = (t_{XL+\Delta X} - t_{XL})/\Delta X. \qquad (7)$$

S-time-step is obtained by simple subtraction of consecutive times in columns in the time matrix in Table 1 if ΔX_L is kept constant.

Using linear approximation, the relationship between S-time-distance and S-time-step for a selected ΔX_L is

$$S_{ij}(X_{L2}) = S_{ij}(X_{L1}) + S_i(X_{L2}\text{-}X_{L1}) - S_j(X_{L2}\text{-}X_{L1}) \qquad (8)$$

Since events are dated in time, in time series comparisons, regressions, models, forecasting and monitoring, the notion of time distance always existed as a "hidden" dimension. What was needed was to systemize and formalize the approach and to define an appropriate statistical measure for operational use. In this paper we apply the time distance approach in a limited way to the international comparisons across world regions and selected countries. In this domain S-time-distance plays a role of a generic concept like static measures of disparity or growth rate.

However, this generic approach can be usefully applied as an important analytical and presentation tool to a wide variety of substantive fields at macro and micro levels. For extensions to measuring deviations between estimated and actual values in regressions and models, forecasting, error in timing and causality, monitoring, and business cycle analysis see Sicherl (1994, 1997), to variables other than time Sicherl (1999). Granger and Jeon (1997, 2003) extended it to comparisons of leading and lagging indicators and used the time distance as a criterion for evaluating forecasting models[8].

[8] 'As Sicherl (1973, 1993) proposes, for a given level of the lagged or leading indicator, a time distance measures distance *in time* between the indicator and the indicated variable. Observed time distance is a dynamic measure of temporal disparity between the two series, intuitively clear, readily measurable, and in transparent units which are comparable across a pairing of indicators and indicated variables. It is suggested that one should complement conventional vertical measures with horizontal measures'. ……'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' (Granger, Jeon, 1997).