# AN ALTERNATIVE MEASURE OF THE DIGITAL DIVIDE BETWEEN ARAB COUNTRIES

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## ABSTRACT

The disparities related to the access and usage of information and communication technologies (ICTs) between developed and developing countries is described as the digital divide in the cross-country analysis. There are a variety of definitions and indicators used to describe the concept and measurement of the digital divide. Most of measures are based on some function of the vertical distance (absolute difference and/or the ratio) between time series of the indicator used to measure the digital divide. In this paper we propose the use of time distance which is the distance (or proximity) in time between the points when two series reach a specified level of a particular ICT indicator. The mutual relationship between alternative measures is discussed and it was illustrated that in some, quite common situations, a conclusion based on these measures about digital divide could be contradictory. Using ICT indicator such as Internet users for Arab countries three measures of the digital divide were calculated and presented in combined, indicator and time distance space. Theoretical and practical consequences of using time distance as a complementary tool in digital divide analysis have been discussed.

**Keywords:** Digital divide, Time distance, S-distance, Internet users, Arab countries

## 1. INTRODUCTION

There are significant differences between countries in how far they went and how fast they adopted new technologies in the economy and society. Unfortunately the digital divide, i.e. differences in opportunities to access and use ICTs for a wide variety of activities appears to be persistent and continues to grow in spite of efforts to reduce it. Campbell [1] showed that numerous ICT indicators indicate a trend toward increasing the digital divide. Various factors influencing ICTs and Internet diffusion have been considered in several studies. Telecommunication infrastructure (Hargittai [2]), socio-economic factors (Robinson and Crenshaw [3]) and cultural values (Maitland and Bauer [4]) have a significant influence on Internet diffusion among countries. Guillén and Suárez [5] demonstrated that the global digital divide, as measured by cross-national differences in Internet use, is the result of the economic, regulatory, and socio-political characteristics of countries and their evolution over time. Chinn and Fairlie [6] identified that the global digital divide (measured by computer and Internet use) is mainly accounted for by income differentials. They also identified demographic variables, infrastructure indicators and regulatory quality to be statistically significant determinants of the global digital divide. Dewan, Ganley and Kraemer [7] reached the same conclusion but added that there are significant differences in the nature of their effects across countries at different stages of adoption. Factors that previously may have been expanding the digital divide with earlier technologies are narrowing the gap as the Internet becomes the key technology.

In this paper we take a step back from these studies focusing on the more fundamental methodological question, challenging the traditional, dominant approach in measuring the degree of disparity between countries, i.e. the degree of the digital divide. For a given time series of an ICT indicator for two countries the traditional approach uses the vertical distance between time series at a certain point in time. To measure the digital divide between two countries we are using a time distance concept based on Pavle Siherl's works (Siherl [8], [9], [10], [11], [12], [13], [14]).

Time distance takes the horizontal difference between two time series, i.e. identifies the time-horizons for one country to catch up with the current level of an ICT indicator in the other country.

The main objective of this study is to discuss the implications of a new statistical measure for measuring the digital divide and to apply it to Arab countries datasets. What is the added value of a new time distance measure? Simultaneous consideration of the static relative/absolute differences and time distance measures of the digital divide was used to answer this question. Results of the gap analysis in two dimensions have theoretical, practical and implications for policy makers which are briefly discussed at the end of this paper.

In the next section a brief discussion of alternative measures of the digital divide is given together with their comparison. The data and results section provides definitions and describes the data used in this study and the results of analysis. The final concluding section discusses the implications of these results.

## 2. THEORETICAL BACKGROUND

Various measures were defined and used to measure digital divide. Usually the relative frequency of observed phenomena (e.g. Internet users per 100 population) which is retained by a certain country was used. Also, the concentration ratio (Gini coefficient) which is used in economics to measure income inequality within and between countries is used [15]. It ranges from 0 (perfect equal distribution, i.e. absence of divide) to 100 (maximum inequality, i.e. maximum divide). When using time series data for two countries some function of the vertical distance between time series was used as the most common basic element for calculation of the digital divide measure between countries.

Let $X_i(t)$ describe the time series or trajectory of the indicator $X$ used for measuring Internet penetration over time in the $i$-th country. For two time series $X_i(t)$ and $X_j(t)$ describing the same phenomenon in $i$-th and $j$-th country, most frequently used measures of digital gap are based on **vertical** differences at a given point of time t, the static absolute difference $A$

$$A_{ij}(t) = X_i(t) - X_j(t) \quad (1)$$

and the static relative difference or ratio R

$$R_{ij}(t) = X_i(t) / X_j(t). \quad (2)$$

Standard approach in measuring a digital gap (digital divide) between two countries is to calculate the static absolute or relative difference between two indicators (for example: Internet access or Internet use) at a certain point in time.

Sicherl ([8], [9] and [16]) introduced a new statistical measure based on **horizontal** differences for a given level of indicator $X_L$. The new measure called *S-distance* or *time distance* is the time difference between points in time when $i$-th and $j$-th country's indicator reached the level $X_L$ , i.e. $X_L = X_i(t_i) = X_j(t_j)$, time distance is defined as

$$S_{ij}(X_L) = T(X_L) = ti(X_L) - tj(X_L) \quad (3)$$

where $T$ is determined by $X_L$. When using indicators such as Internet penetration or Internet use which have the shape of the standard diffusion process curve, $T$ is a function of the level of the indicator $X_L$. For a more formal definition of time distance see [17].

The following theoretical discussion is based on [10], [11], [12], [13] and [14]. To illustrate the notion that time distance measure is adding a new dimension to the digital divide analysis two diffusion curves are presented in Figure 1. Two scenarios are assumed: scenario A assumes 4% growth rate for diffusion curves 1 and 2, while scenario B assumes 1% growth rate. To make this illustration simpler it was assumed that the indicators in both countries for which the diffusion curves are presented are growing at the same rate. The level of diffusion curve 1 is 10% higher than the level of diffusion curve 2. Standard statistical measures such as static relative difference,

percentage difference, and Gini coefficient would show the same value in the observed period. For example, static relative differences (denoted $R_{12}(t)$) would have the same values (1.1) in both scenarios, showing the same degree of disparity. On the other hand, including the time distance dimension in analysis in scenario A with 4% growth rate time distance between two countries is 2.5 years, while in scenario B with 1% growth rate time distance is 6.3 years, which means that the digital divide increased in case of scenario B. Clearly, static relative differences do not take into account that the growth rates had an effect on the degree of disparity. Obviously if we ask people to compare these two scenarios, scenario A with 10% disparity and 2.5 year time distance and scenario B with 10% disparity and 6.3 years of time distance, they would not perceive it as an equal degree of disparity.

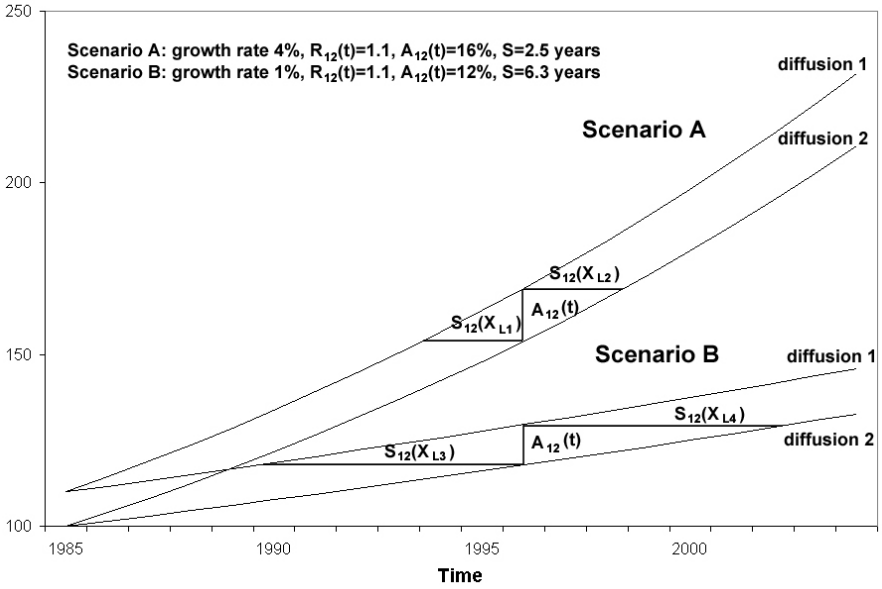


**Figure 1:** Static relative and absolute differences and time distance for two diffusion curves

The time distance measure opens the possibility for simultaneous two-dimensional comparisons of time series data: vertically (standard measures of static difference) as well as horizontally (time distance), providing a new dimension of analysis to a variety of problems including the digital divide. However, the time distance (S-distance) measure could be used not just to measure the digital divide but also in other fields, for example to measure deviations between estimated and actual values in regressions and models [16]. One of the most significant contributions to the theory and application of time distance was made by Nobel Prize winner Professor Clive Granger. Granger together with Jeon [19] extended the time distance measure to econometric forecasting as a criterion for evaluating forecasting models for leading and lagging indicators.

Table 1 identifies 9 different cases that may emerge when comparing results of a static relative measure and time distance measure. Upward and downward oriented arrows illustrate whether the ratio or S-distance measure suggest that the digital divide increases or decreases. Equal sign suggests no changes in the digital divide between two countries. For example, the case 4 should read: static relative difference suggests no changes in the digital divide while S-distance suggests that the digital divide increased.

Only in the cases described in the diagonal cells conclusion about digital divide between two countries based on two measures is the same. In the case of cell 3 and 7 two measures are suggesting contradictory conclusion, i.e. the digital divide between two countries is increasing and decreasing at the same time. Occurrence of the case 3 and 7 is not rare as we illustrate in the next section. Therefore we argue for using the framework which encompasses both dimensions, i.e. static relative difference and time distance measure.

**Table 1:** Convergence in two dimensions: Proximity in time and in indicator space
(3 x 3 classification of cases)

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

Usually, the notion of convergence is linked to a decrease in relative static measure (ratio or percentage) over time. However, as Sicherl [9] showed, the decrease in the ratio of the values of the indicator between two countries depends only on the differences between their growth rates for this indicator, while the time distance depends both on the differences between their growth rates and the absolute value of the growth rate of the indicator. Consequently, convergence (divergence) should be discussed in two dimensions: closer/farther in static relative difference and closer/farther in time distance.

## 3. DATA AND RESULTS

Data for this article was collected from the International Telecommunication Union Yearbook (ITU [20]). We selected the *Internet users per 100 population (ITU estimates)* indicator to measure the level of Internet penetration in each Arab country. According to the International Telecommunication Union this indicator (denoted further in the paper as INTERNET USERS) is the number of persons using the Internet divided by the number of all persons present in the country (de facto population) at the time of the census.

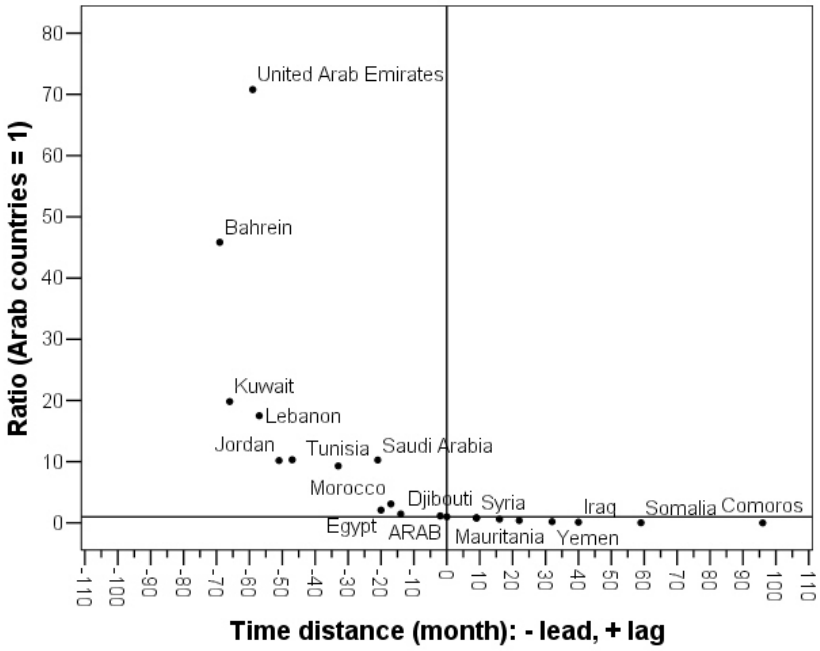


**Figure 2:** Gap analysis in two dimensions for INTERNET USERS indicator for Arab countries in 2001.

The static relative difference and time distance for 20 Arab countries and INTERNET USERS indicator were calculated (relative to the average value for all Arab countries) and presented in Figure 2. The two measures of digital divide suggested a different conclusion in terms of the relative position of these countries. While Bahrain and Kuwait are among leading countries in terms of Internet penetration with 69 and 66 months lead time respectively in comparison to the average value of INTERNET USERS for all Arab countries, the static relative differences for these two countries are significantly different, i.e. Bahrain achieved 45.84 times of the average INTERNET USERS level for all Arab countries in 2001 and Kuwait achieved only 19.83 times of the same level. A different example is found in case of Jordan and Saudi Arabia. Both countries achieved about 10 times of the average INTERNET USERS level for all Arab countries but the time distances are different, Saudi Arabia is about 51 months ahead of the average value for all Arab countries compared to Jordan's 21 months.

Depending on the measure used in analysis (static relative difference or time distance) conclusions about the degree of disparity in the two dimensions are different. In the further analysis we are focusing on the individual country data and the calculation of different measures is based on the whole time series. The most simple case seems to be when both time series diverge from each other, i.e. when the digital divide gap is increasing. This is the case with INTERNET USERS time series for countries such as Bahrain, Kuwait, Oman and Saudi Arabia. However, even in these cases the static relative difference and time distance could move in opposite direction as we illustrate further.

**Table 2:** Internet users per 100 population and digital divide measures

| Year | INTERNET USERS (Egypt) (1) | INTERNET USERS (average) (2) | Absolute difference (3)= (1)-(2) | Relative difference (4)= (1)/(2)% | Percentage difference (5)= (4)-100 | Growth rate (Egypt) (6) | Growth rate (average) (7) | Time distance (8)= (1) : (2) |
|---|---|---|---|---|---|---|---|---|
| 1993 | 0.001 | 0.000 | 0.001 | 3.73 | -96.27 | | | - |
| 1994 | 0.007 | 0.001 | 0.006 | 7.87 | -92.13 | 5.54 | 2.10 | - |
| 1995 | 0.034 | 0.004 | 0.030 | 8.28 | -91.72 | 3.95 | 3.70 | - |
| 1996 | 0.067 | 0.010 | 0.058 | 7.05 | -92.95 | 0.96 | 1.31 | -24 |
| 1997 | 0.099 | 0.031 | 0.068 | 3.16 | -96.84 | 0.47 | 2.29 | -25 |
| 1998 | 0.163 | 0.064 | 0.098 | 2.53 | -97.47 | 0.64 | 1.05 | -25 |
| 1999 | 0.320 | 0.153 | 0.168 | 2.10 | -97.90 | 0.97 | 1.37 | -13 |
| 2000 | 0.709 | 0.338 | 0.371 | 2.10 | -97.90 | 1.21 | 1.21 | -11 |
| 2001 | 0.930 | 0.443 | 0.486 | 2.10 | -97.90 | 0.31 | 0.31 | -20 |

A more difficult case for analysis of the digital divide is when two country's time series show no clear divergence or convergence. As an illustration of such a case time series for Egypt and the average value for Arab countries were selected. In Table 2 original data and calculated various measures based on INTERNET USERS data were presented. The original INTERNET USERS time series for Egypt and average value for all Arab countries (data in column (1) and (2)) are presented in Figure 3.

Based on static relative differences data presented in column (4) of Table 2 one could conclude that the digital gap between Egypt and all Arab countries has been becoming smaller since 1995. However, using the time distance measure our conclusion would be quite different. Until 1998 the time distance between INTERNET USERS in Egypt and all Arab countries was almost constant (Egypt was ahead for about 25 months) but after 1998 decreased to 11 months and than in 2001 increased again to 20 months. Therefore simultaneous evaluation of static relative differences and time distance measures in the gap analysis on the same graph is highly recommended.

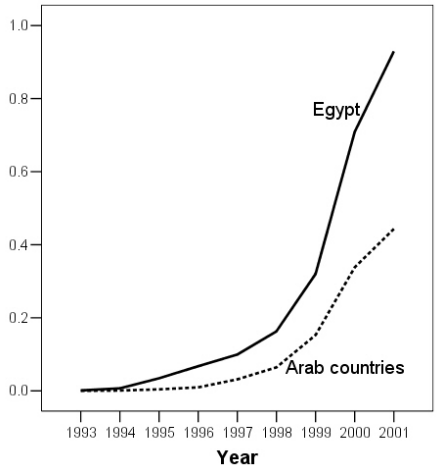


**Figure 3:** INTERNET USERS for Egypt and all Arab countries (average)

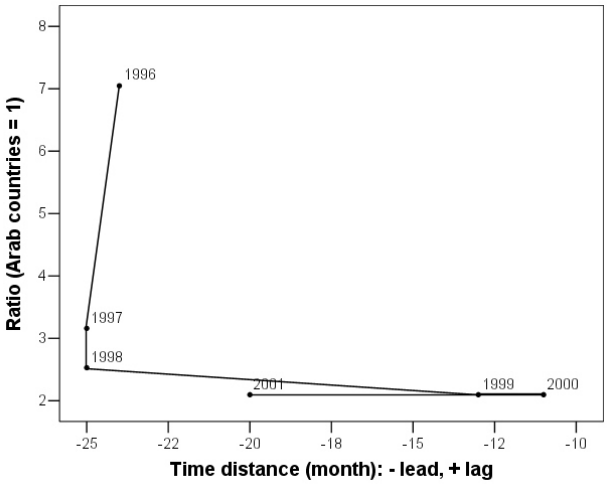


**Figure 4:** Gap analysis in two dimensions for INTERNET USERS indicator for Egypt

The case of the digital divide between Egypt and all Arab countries is more interesting to analyse using a gap analysis in two dimensions (Figure 4) because of the mixed conclusions that could be reached. Roughly speaking there are two sub periods: the first period from 1996-1998 when the time distance is almost constant and the value of the ratio is declining and the second period from 1998-2001 when the ratio is almost constant and the time distance varies between 11 and 25 months. We can go even further and analyse the relationship between these two measures in the smaller defined sub periods. Using INTERNET USERS as an indicator of usage of ICT, four sub-periods were identified with quite distinct behavior between the static relative difference measure (Ratio) and time distance measure (S-distance):

(1) 1996-98 Ratio ↓ S-distance = (case 8 in Table 1)
(2) 1998-99 Ratio ↓/= S-distance ↓ (case 9/case 6 in Table 1)
(3) 1999-00 Ratio = S-distance ↓ (case 6 in Table 1)
(4) 2000-01 Ratio = S-distance ↑ (case 4 in Table 1)

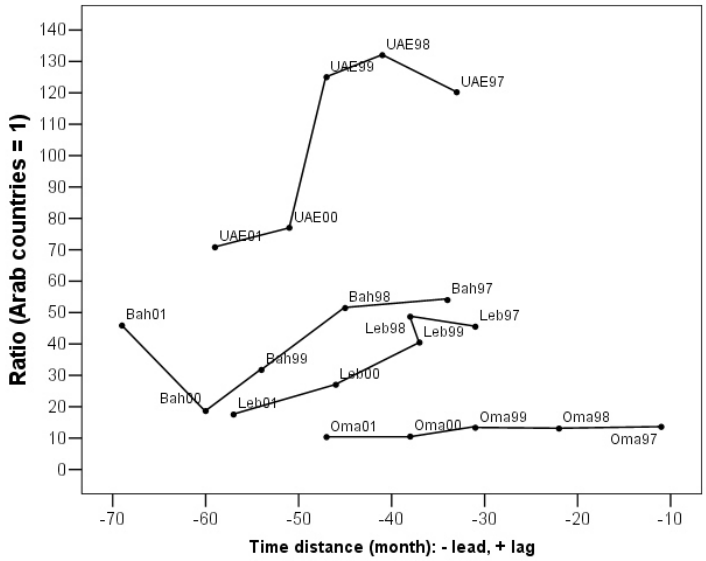


**Figure 5:** Gap analysis in two dimensions for INTERNET USERS indicator for selected Arab countries

Finally, we found similar patterns in the gap analysis for selected Arab countries presented in Figure 5. The pattern for the following Arab countries: Bahrain, Lebanon, Oman and United Arab Emirates clearly illustrates that ratio (static relative differences) tends to decrease in period 1997-2001. This would suggest that the digital gap between these countries and the average value for all Arab countries are shortening, though the gap is still large. In the same period the lead time for these countries increased for almost 3 years on average suggesting improvement in their position in comparison to the average value based on data for all Arab countries. In other words, based on the time distance measure we would conclude that the digital gap between them and the average value increased. This obvious contradiction in conclusions should be address in the right way by taking the both dimensions (time dimension and indicator space) into consideration.

## CONCLUSION AND IMPLICATIONS

This study is designed to examine the use of time distance, an alternative statistical measure for measuring digital divide at the country level. The concept and use of the time distance to measure digital divide is very simple. Because of the differences in the measurement units of various ICT indicators some people may have difficulties understanding the degree of disparity between countries. However, most people would have no problem with the notion of time built into the time distance measure and its measurement unit (month, or year). Everyone would understand what it means when a country is leading or lagging some other country by 12 or 18 months with respect to the selected ICT indicator.

There is an even more important methodological reason for using the time distance measure. A standard approach based on the ratio of the values of the ICT indicator between two countries could lead toward a wrong conclusion because this ratio depends only on the differences between their growth rates for this ICT indicator. On the other hand, the time distance depends both on the differences between their growth rates and on the absolute value of the growth rate of the ICT indicator. This calls for representation of the static relative difference and time distance on the same graph so that we can see how the digital divide is changing through time.

Using the Arab countries the Internet users dataset it was clearly illustrated that quite often contradictory conclusions could be reached when analysing the digital divide between countries. In the case of Eqypt and average value for all Arab countries it was shown that alternative static digital divide measures are not moving in the same direction as the time distance measure implying mixed conclusions with regard to the digital divide between Arab countries.

This study has implications both for theory and policy makers. The concept of time distance offers a new insight into the digital divide problem. This new statistical measure brings a new presentation tool for policy analysts by expressing the gap in time units which is readily understood by general public. This measure helps to show how many years ahead or behind the ICT indicator of a given country is; this is a function of its rate of progress as well as the initial digital gap between two countries. So, the critical variable for policymakers to monitor is the annual rate of change, which determines whether lagging countries are catching up as well as making progress. Therefore the information contained in the time distance measure affects the analytical and decision-making level by providing new insights for the evaluation of policy and business alternatives.

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