Theories of the Digital Divide: Critical Comparison

James Pick  
University of Redlands  
james_pick@redlands.edu

Avijit Sarkar  
University of Redlands  
avijit_sarkar@redlands.edu

Abstract

Digital divide research has benefitted from theories that account for unevenness between individuals, households, and geographic units in access to, and use of information and communications technologies (ICTs). The objective of this paper is to explain and examine important digital divide theories, compare and contrast their major features, and identify appropriate methodologies to test them. Four theories examined are Adoption-Diffusion Theory (ADT), van Dijk’s Theory of Digital Technology Access and Societal Impacts, Unified Theory of Acceptance and Use of Technology (UTAUT), and Spatially Aware Technology Utilization Model (SATUM). The theories are compared based on their independent and outcome factors, units of analysis, spatial components, and amount of scholarly literature. The methodologies utilized depend on sample size and range from varied regression and multinominal logit models to structured equation modeling, event history, and spatial analyses. The strengths and weaknesses of the digital divide theories are compared and can inform investigators on appropriate theoretical choice for particular settings.

1. Introduction

The adoption, diffusion, and utilization of information and communications technologies (ICTs) and disparities in such adoption and use have been the subject of extensive research for well over two decades. As the term “digital divide” originated in the mid-late 1990s and subsequently gained popularity, researchers in multiple spheres – information systems and technology, business, economics, and management, and the social sciences have examined multiple aspects of the digital divide.

The Organization for Economic Cooperation and Development has defined the term digital divide as the “gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access ICTs and to their use of the Internet for a wide variety of activities” [22]. Consistent with this definition, prior research has largely contended that the digital divide should be defined in terms of both access and use of ICTs [10,11,13,30,39]. Access and use of ICTs in digital divide studies have been examined at various levels – from the level of the individual [1,2,5], household [35], up to multi-national [6,14,15] or global [24,27,31] levels. Spatial scales of digital divide studies have also varied. While studies at the micro-regional [13,15] level are somewhat common, sub-national (state, county, or zip-code) studies [9,24] for an entire nation are less common, perhaps due to the challenge of obtaining systematically reliable data on ICT indicators as well as their correlates at that level for all provinces/regions/states/counties of an entire nation.

To conduct investigations related to the access, adoption, and use of ICTs, a number of theories have been posited and developed over the years. The objective of this paper is to examine four theories that have been either been adapted or posited to examine digital divides – (i) Adoption-Diffusion Theory (ADT), (ii) Van Dijk’s Model of Digital Technology Access, (iii) Unified Theory of Acceptance and Use of Technology (UTAUT), and (iv) Spatially Aware Technology Utilization Model (SATUM). The last model has been developed and implemented for recent studies of the digital divide at the global, national, and sub-national (state or provincial) level and is unique due to its explicit modeling of spatial autocorrelation of ICT indicators as well as their independent correlates.

This paper examines, compares, and contrasts four models – ADT, Van Dijk’s model, UTAUT, and SATUM – in terms of their origin, conceptual foundations, scope, and applicability to digital divide studies. Preliminary recommendations on applications of these models are outlined for digital divide researchers with the objective of addressing theoretical shortcomings in digital divide research [33].

The research question is – what are the important features of four leading theories of the digital divide, how do the features compare and contrast with each other, and what are the pros and cons of the theories.

The remainder of this article is comprised of sections on ADT, Van Dijk’s model, UTAUT, SATUM, comparison of these four models, and evaluative remarks along with recommendations for
adoption based on each theory’s pros and cons, and conclusions.

2. Adoption-Diffusion Theory

2.1. Background and Description

Adoption-diffusion theory (ADT) originated from studies of the adoption and diffusion of varied innovations in the 1950s and early 1960s. One of the researchers on agricultural innovations, Everett Rogers, went on to consolidate the diverse knowledge on the innovations into an extensive theory of adoption and diffusion of innovations [28], a foundation volume on which went through editions up to the last one [29].

ADT was not developed with a focus on digital divide, but rather offered as a theory that applied widely across diverse fields, including diffusion of prescription drugs, spread of new varieties of crops, photovoltaic solar receptors, and market spread of electronic games, laptops, personal computers, and cell phones.

The broad-based range of innovations has pluses and minuses for a digital divide theory. An advantage is greater robustness for the varied and temporally changing mix of technologies, while, on the minus side, the theory may miss some of the refinements of factors and process steps customized for ICTs.

Adoption diffusion theory applies to the process of adopting an innovation for use and diffusing its use within a population of potential users over time. Hence, for digital divide theory, ADT must be applicable to situations in which there is an unfolding over time of the spread of an ICT.

Another key building block of ADT is that the ICT innovation is posited to be communicated through communication channels to prospective new adopters. This aspect implies that models fully built based on ADT need to take into account the transmission pathways for information about the innovation. A further key aspect is that ADT is viewed as occurring within a social system, so that system needs to studied and understood in applying the theory.

The innovation is a new product or service relative to the social system environment. In the Silicon Valley, a 3-D cell phone is today not an innovation, but approaching a standard everyday item, whereas in many central African nations it remains an innovation utilized by a very small proportion of the population. Since technologies are advancing rapidly worldwide [25], investigators of an ADT innovation need to confirm that it remains so in the society being studied.

In ADT, innovations are measured on the basis of the following five attributes [29].

Relative advantage. This represents the advantage the innovation has on whatever product or service proceeded it, or if totally new, relative advantage over nothing previously.

Compatibility. This reflects how much the innovation is compatible with the contemporary values, experiences, and user needs. Education can contribute to gaining greater compatibility for an innovation.

Complexity. It reflects the inherent complexity of design and use of a product or service. For instance, servers are often regarded as complex, but vendors have realized this and are trying to re-design them to be simpler to use.

Trialability. Trialability refers to how easy or difficult it is to prototype and test an innovation. An ICT that is quite trialable is likely to be adopted more readily than one that requires extensive and challenging testing.

Observability. This reflects how visible the innovation is. It is somewhat connected with the aforementioned need for communication, since a very observable ICT product would encourage early adoption and would diffuse later on more rapidly.

These attributes, which are not present in the other digital divide theories examined in this paper, are linked to the appeal of the product or service. There is some overlap with the construct in Technology Acceptance Model (TAM) of perceived ease of use [7]. However, ADT is much more detailed in identifying facets of ease of use and how it is perceived.

Another key aspect of ADT is the sequential stages of adopters and diffusers, who are categorized as innovators, early adopters, early majority, late majority, and laggards [29]. The incidence of these in a population is posited to follow a normal curve with the early and late majority together comprising 67 percent of the temporal process [29]. If the process is viewed cumulatively, the function is S-shaped, with slow initial adoption followed by rapid take-off (early and late majority) and flattening out with laggards.

A further enhancement of ADT is to include geography in the model [29]. A neighborhood effect was noted in the diffusion process, in which innovations were more likely to spread from a current adopter to new ones nearby, rather than at a distance. The models were empirically tested in rural Sweden and general rules established [12]. Spatial clustering of adopters was noted for adoption of window air conditioners in clusters of contiguous houses in a Philadelphia suburb and for diffusion of family planning innovations in a Korean Village [23]. Although the spatial enhancement is uncommon in ADT studies, it is becoming more prevalent and is applied in the ADT example.
2.2. Example

An example of a spatial ADT study is the adoption and diffusion of a technology-based customer loyalty program of a very large retailer in a major U.S. city [3]. The Rogers ADT, supplemented by additions [17] was applied to daily data on 18,000 adopters over a one year period, whose home location was known and who lived within 35 miles of the central store. Adopters were divided into three stages corresponding to the framework in [29]. The model took into account the effects of covariates of store distance from the use, number of billboards present for the user, number of earliest adopters (innovators) present in the neighborhood and whether or not radio marketing events were present.

The study was conducted using mapping and event history models, i.e. models that account for distinctive changes at time points in the way a user is categorized. Results indicated that the spread of information was the driving factor, a finding corroborating the importance of communications in the ADT model. The “innovators” (earliest adopting group) were very influential in forming “diffusion cells,” i.e. small neighborhood areas of intense diffusion, which were identified through analysis of the evolving mapping. Also each covariate had significant influence on the rates of diffusion of the loyalty program [3].

This study demonstrates the relevance of ADT to adoption patterns of a technology-based service innovation (loyalty program) in a large city. It traces the adoption and diffusion patterns over time as well as in space. It underscores the longitudinal strength of this theory, as well as the need for intensive data collection and analysis.

3. Van Dijk’s Theory

3.1. Background and Description

The theory of the digital divide of Jan A.G.M. van Dijk was developed over a ten year period, culminating in its full and mature presentation and explanation in book form [32]. The core of the theory posits that inequalities of personal position and background result in inequalities in resources for the individual, which lead in turn to inequalities of access and finally to disparities in participation by the individual in society. That participation in turn feeds back to positional characteristics which forms a full feedback loop. The fundamental assumption is that inequalities are perpetuated throughout the entire process of accessing and using technologies in society. The model steps are not given formal prominence in the theory. The full model is shown in Figure 1.

The individual’s positional characteristics are indicators known in the digital divide literature to be influences on technology access and use [25]. These characteristics for van Dijk theory contribute to inequalities in digitally-related resources for persons.

Personal characteristics are posited also to influence resources. A person’s age, gender, intelligence, and health can impact extent of resources. For instance, mental (knowledge) resources available would be different for a young, intelligent, healthy female versus an elderly, ill, and less intelligent male. The personal characteristics similarly can contribute to amount of time available for digital activities, for instance certain illnesses might limit time available.

![Figure 1. Theory of van Dijk, modified from [32]](image)

Inequalities among combinations of personal and positional categories impact the amount of resources a person has. Hence, the resources including time, material, social, cultural and knowledge-mental, are also unequally distributed.

In the theory, unequal resources combined with the unequal process of developing access lead to the full factor of access. The access process steps are delimited in the theory as a circular process of motivation for access, access to material hardware and software, developing ICT skills and gaining access to usage. This feedback process takes place over time and often through iterative steps.

Finally, once overall access is achieved, almost certainly with inequalities, access leads to societal impacts, which include impacts on the economy, culture, politics, institutions, and through social networks, and in geographical locations [34,35].

This theory is more complex that ADT and emphasizes inequalities among the starting characteristics of an individual and in the process of...
gaining resources and access to ICT. The determinants of the digital inequalities can be traced through this model to possible causes, for instance a positional aspect might be a barrier all along the way in ICT access, for instance, positionally, a store clerk in rural India would have less access than the owner of the store chain. Regarding the technological base characteristics, people at the bottom of the pyramid might not be able to afford 3-G phones or full-featured laptops. The positional and personal inequalities can be further reinforced by social exclusion, exploitation, and/or by control exerted by people in power [32].

The theory is exemplified in East Asia, a part of the world that is configured to deny the unprivileged ICT use, in a way explainable by this model [32]. East Asia has some nations that are leaders in manufacturing ICT hardware, such as Japan, South Korea, Singapore, Hong Kong, and mainland China. In these nations, large-scale government programs have stimulated production of hardware infrastructure, such as the Singapore One Project and Cyber Korea 21. The nations’ policymakers have often claimed that the hardware production would lead to nearly 100 percent usage of ICT. However, although large advances occurred in ICT access and usage, ICT inequalities remain today in all those nations [25,32].

3.2. Process of formulating the theory

The van Dijk theory was developed specifically to account for the digital divide. The sources used to develop it were largely surveys and policy studies done on ICT access and usage in the Netherlands, U.S., and other advanced nations. The theory was not induced from the extensive digital divide research literature that is centered in the economics, sociology, and information systems disciplines. Rather, the theory’s originator had developed parts of the theory in a series of smaller studies in the decade preceding its full introduction. The theory’s non-dependence on the broad literature might also be a reason it has not been widely incorporated into the disciplines mentioned.

3.3. Example

A study that focuses on inequality in skills and usage exemplifies application of this theory [36]. The causal model is simplified from the full van Dijk model. It includes all the major factors from the full theory, i.e. position and personal categorical inequalities influence distribution of resources, which in turns results in differential access to ICTs and to varying participation in society. What is missing from the full model is the more detailed sub-model of access, seen in the lower part of Figure 1.

Parts of this model were tested with Dutch samples, both in this paper and in cited concurrent co-authored papers. Among the findings are that advantages of internet use on Dutch samples in 2011 showed 40 percent positive answers on a variety of usage areas, but large disparities remaining between respondents of different age, educational background, and gender [36].

The implication is that, although the digital divide for physical access is closing, differences in skills combine with preferences for specific internet usage applications, so the unequal skills and usage persist [36]. In emphasizing positional and personal inequalities as the starting point of the theory, these skills differences are posited to have the prominent role that the author’s findings confirm in the example study.

4. Unified Theory of Acceptance and Use of Technology (UTAUT)

4.1. Background

The Unified Theory of Acceptance and Use of Technology (UTAUT) combined features from eight information technology acceptance research theories to explain technology acceptance at the individual level [37]. UTAUT’s dependent variable – behavioral intention (BI) – the degree to which an individual wishes to use a technology for personal activities depends on the model’s key constructs – expected performance and effort, and also on social influences [18,37]. Final use behavior of an individual depends on BI as well as facilitating conditions. The factors – gender, age, voluntariness, and experience moderate the relationship between UTAUT’s key constructs and the dependent variable – behavioral intention. Note that the gender and age are key demographic factors that have often been identified as key determinants of ICT access in the digital divide literature [37].

While UTAUT [37] has been widely cited, a recent meta-analysis has found that subsequent to its original development, empirical testing of UTAUT and its constructs has been somewhat limited.

4.2. Relevance to digital divide

Over the years, researchers have largely agreed that the digital divide should be defined both in terms of access and use [40]. UTAUT predominantly addresses acceptance and use of technology, but not access. Access of ICTs has been measured and meticulously tracked at the global and national level with increasing rigor by organizations such as the International...
Telecommunications Union (ITU), World Economic Forum (WEF), and National Telecommunications and Information Administration (NTIA) [21] and such data are widely available. Tracking and recording use of ICTs – especially at the individual level, while increasingly common for the purpose of gathering intelligence and performing analytics, is however conducted both by governments as well as by private sector telecommunications companies. Such data are often hard to find, may be costly, and data collection methodologies are largely unknown or undocumented with few exceptions. As a result, digital divide conceptual models of ICT adoption and use at the individual level have not embraced UTAUT or its constructs for the most part with a few exceptions [8,18].

4.3. Example

A recent study [18] employed UTAUT to examine internet adoption and use by the elderly – adults over 65 years of age. UTAUT in its foundational form as well as UTAUT enhanced by moderating demographic factors – age, gender, education, and income were both employed to understand which model provides a better explanation of the intention to adopt the Internet by the elderly. Age was introduced as a moderating factor since perceived effort, a key construct of UTAUT was posited to be of different importance to younger seniors than to older seniors.

The study found that enhancing UTAUT with socio-demographic factors increased the predictive power of the model without making the model overly complex since the moderating factors were measured in a straightforward fashion. The study [18] interestingly found an effect of age within the group of the elderly. In the extended UTAUT model, age had a negative effect on behavioral intention (BI) as well as a significant moderating impact on the relationship between performance expectation and BI. The authors reasoned that the expected performance of the Internet (and IT in general) has a greater influence on the intention to use this technology for older elderly than for younger elderly individuals.

The study enriches digital divide research, especially models which refer to different types of access, such as material, skill, and motivational access [32] by providing solid measurement instruments for the purpose of empirical validation. It also points to the possibility of further enhancing UTAUT with variables such as race and ethnicity, family structure, culture, language spoken, geography/location, and other psychological factors – important determinants of ICT access and use in the digital divide literature [40]. Another possibility is to incorporate the model to investigate technology usage among homogenous social groups analogous to the example study described in this section [18].

5. Spatially Aware Technology Utilization Model (SATUM)

5.1. Background

Demographic and socio-economic factors such as race and ethnicity, age, gender, income, education, family structure, economic development indicators such as GDP per capita, per capita manufacturing expenditure, services workforce, market structure, cost of ICT access, public policy, infrastructural factors such as availability of electricity [40] have been posited and empirically tested in the digital divide literature to be associated with indicators of ICT access and utilization. While these factors are implicitly spatial, another explicitly spatial factor – the extent of urbanization has often been included in models examining technology adoption and found to have significant association with ICT dependent variables. However, prior digital divide literature has been largely mute about the possible presence of spatial autocorrelation in error terms while using standard multivariate approaches. Spatial autocorrelation in error terms implies that the geographic forces are exogenous to the conceptual model [16]. Furthermore, ICT dependent variables are also not screened for spatial autocorrelation. In other words, are regions, provinces, or communities with high/low levels of technology adoption simply impacted by the geographic proximity to regions, provinces, or communities with similar levels of ICT adoption? This is typically ignored and unincorporated in most digital divide theoretical models in the MIS literature and runs contrary to the precept that digital divides pertain to people and organizations – and where they live or are located. Geographers Tony Grubesic [9,10] and Barney Warf [38] have however acknowledged the geography of digital divides. The Spatially Aware Technology Utilization Model (SATUM) remedies these deficiencies and explicitly accounts for spatial effects.

5.2. SATUM’s Induction approach

SATUM posits associations of traditionally acknowledged demographic, socio-economic, economic development, market structure, policy, and infrastructure-related factors with indicators of ICT adoption and use dependent variables. Indicators for most of the independent factors, for example, college education, per capita services workforce, percent of
urban population, governmental support for ICT, and others are induced from prior literature. In addition, SATUM has included societal openness since an open and free society is more likely to foster the use of technology to communicate and exchange information. SATUM has been further refined to include indicators of social capital as socially connected individuals and communities support the technologically challenged and provide access to resources (both materials and skills access [1,4,5,20]). For the sake of brevity, independent correlates and indicators of ICT access and use included in SATUM are shown in Figure 2.

**Figure 2. SATUM Conceptual Model**

It is important to note that SATUM has been used for examination of global digital divide and the digital divide in the African continent at the country unit of analysis as well as for sub-national digital divide studies of China, India, Japan, and the US at the state/provincial unit of analysis [19,23,24,26]. Variables included in SATUM are customized for each of these studies depending upon their availability at the country, state, or provincial level. Also note that foundationally, SATUM has been conceptualized for global, macro-regional, or provincial studies of the digital divide; therefore it is unsuitable to examine digital divide at the individual or household level.

The model is operationalized using (i) descriptive mapping of ICT dependent variables and their independent correlates to recognize geographic patterns, (ii) cluster analysis (K-means) of dependent variables to explore high- and low-value ICT agglomerations, (iii) Moran’s I, an index for spatial autocorrelation [9,16] to test spatial autocorrelation of each dependent variable, and (iv) confirmatory analysis using standard multivariate methods to test posited associations of independent correlates with ICT access and use indicators. Finally diagnostic tests (Joint Wald, Koenker, and Jarque Bera) confirm if regression residuals meet standard OLS regression assumptions and residuals are tested to detect the presence of spatial bias (autocorrelation), again using Moran’s I.

### 5.3. Example

Employing SATUM, the digital divide in the fifty US states has been examined [24]. Several indicators of ICT adoption and access – for example, desktops/laptops, internet, broadband, cell phone, fixed phone, and mobile wireless device subscription are highly spatially agglomerated in US states; however the adoption of social media (Facebook and Twitter) is spatially random. Cluster analysis reveals the presence of four clusters – two of which are bi-coastal and at the high end of ICT adoption, while a cluster of states in the South, with the exception of the state of Georgia lags in ICT access and usage. Leading determinants of ICT adoption are social capital, societal openness, college education, and ethnicities, followed by urbanization and R&D expenditure by the states – a finding that reinforces the importance of innovation in alleviating digital divides. The use of SATUM also greatly alleviated spatial autocorrelation with 75 percent of dependent variables exhibiting randomness in regression residuals indicating that the model accounted endogenously for most of the geographic forces affecting utilization of ICTs in the US states. An example of non-random spatial distribution of regression residuals for the ICT indicator desktop/laptop in household reinforces the need for screening regressions results for the presence of spatial bias [24] and indicates that findings from this particular regression need to be addressed with caution.

### 6. Comparison of the Four Theories

#### 6.1. Methodologies that apply for four theories

Table 1 compares important features of the four theories in terms of their theoretical underpinning, independent factors, outcome factors, units of analysis, presence of a spatial component, and extent of empirical testing. The four theories have a variety of methodologies in use, often a choice of several for one theory. Table 2 indicates methodologies that have been utilized in prominent studies based on each theory.

Overall, there is quite a range, including event-history modeling, OLS regression, multinomial logit, structural equation modeling (SEM), two-stage regression, econometric, mapping, spatial cluster analysis, spatial autocorrelation, and case studies. Choice of methodology is driven by the availability of
data on particular variables and also by sample size. Certain methods, such as SEM commonly require samples of 100 or more for even simple models. Other methods benefit by larger samples even if not required. Large and robust samples tend to be developed by governments, although more unstructured sources of “big data” are becoming available.

6.2. Advantages and drawbacks of the four theories

The four digital divide theories highlighted in this paper are all useful for examining dimensions, aspects, and levels of the digital divide. A general theory might not be possible for the following reasons: the environments and technologies continue to evolve rapidly; the data available for one particular study may be better suited for a certain theory rather than others; and external factors outside the general theory may turn out to be influential. For instance, leadership might be exceptional and difficult to include in a general model. Accordingly, this section does not attempt to formulate a general theory of the digital divide, but rather argues for the pros and cons of each of the theories. The advantages and drawbacks of the four theories are detailed in Table 3. The usefulness of each of the theories for an investigator depends on the study objective, type of study and underlying context.

ADT. This theory accounts for adoption of innovative technologies over time. It focuses the investigator on circumstances in the environment of the innovative technology that favor rapidity of adoption and an ultimate plateau of adoption. For digital divide studies, it allows comparison of trajectories of adoption and diffusion between nations, states, market territories, or between other societal, business, or governmental units. ADT can help the investigator to account for why a technology is gaining higher level of adoption in one societal unit versus another. Further, it can compare the trajectories of a group of technologies over time. Hence, it is strongly recommended for digital divide studies that aspire to explain or compare the dynamics of digital divides on the basis of differential adoption and diffusion over time.

The drawbacks of ADT are its lack of concern with the behavioral and social forces impacting the individual in his/her adoption decision. Also, the broader societal, cultural, and economic environment and forces are not considered. For instance, an ICT innovation can fail even if it is easily used and offers advantages, as long as the societal or cultural norms are opposed to its adoption. A further drawback is that ADT is focused on access to a technology, but not on the use of the technology, although a variation of ADT, known as Use Diffusion Theory (UDT) does focus on the use of technology [30].

van Dijk Theory. The van Dijk Theory has the advantage of a design that takes into account multiple and complex pathways that encompass inequalities leading ultimately to digital inequalities. The theory’s processes form a feedback loop, so socio-economic-political inequalities eventually lead to digital access inequalities and unequal societal impacts, which in turn can serve as input to another iteration. If a digital divide research project, with suitable data, has a focus on economic, social, political and social class inequalities as drivers of the digital divide, this theory provides a strong framework to trace the pathways that lead from one inequality to another.

The drawbacks of the van Dijk Theory are that varied units of analysis are intermixed, so data collection can involve multiple data sources. Further, the complexity of the theory adds to difficulties in data collection for samples; hence it is more applicable to case studies.

UTAUT. The advantages of the theory are that its formulation is rooted in a combination of eight well-accepted ICT theories of acceptance and use of technology. Another plus is that appropriate sample surveys based on UTAUT can be fairly readily designed and collected. It has a broad literature with which to make model adjustments and interpret and compare findings. UTAUT’s dependent variable of behavioral intention to use ICT is suitable for digital divide research. For survey-based digital divide research that compares ranges of acceptance and use of technologies by individuals, UTAUT is a solid choice.

Drawbacks of the theory include its focus on ICT use by the individual, so it is rarely applied to larger units of analysis, such as counties, entire organizations, or nations. UTAUT does not include ICT access as a dependent variable, so it is not suitable to the substantial body of digital divide investigation focused on estimating access. It does not support longitudinal research of digital divide changes.

SATUM. This theory supports research on combined effects of a variety of social, economic, and political determinants on almost any kind of ICT, a major advantage. SATUM was formulated based on a large base of digital divide literature, and it can be utilized with units of analysis that vary from the individual, to counties, states/provinces, and nations. Another advantage is that often reliable data are available from government and nonprofit sources for empirical testing. A noticeable characteristic is that SATUM also has spatial relationships included as components, so a study can evaluate the extent of spatial bias in multivariate statistical testing and perform other geographical analysis. SATUM is a good
choice for research on digital divides between geographical areas or societal groupings, in which socio-economic-political determinants are analyzed.

SATUM however does not provide for multi-level and/or multi-directional pathways of influence. Another drawback is that the model does not include individual-level psychological factors such as motivation, behavioral intention, and satisfaction.

A single best theory among these four for all occasions does not exist, but rather each theory has appropriate problems, settings, and contexts for which it is the best choice for a particular investigation. This section is intended to help the researcher make the best choice for his/her digital divide setting, given the data available for testing, and the needs of the ultimate consumer of the study findings.

7. Conclusion

This paper explains, compares, and contrasts four leading theories of the digital divide. Each theory is shown to have strengths that make it appropriate as the best choice for certain empirical studies. The summary comparison analyzes differences in the theoretical features of independent factors, outcome factors, units of analysis, spatial components, and volume of prior literature. ADT is based on the impacts of features and spreading of adoption of innovations over time on individuals or households. Van Dijk’s theory is concerned with complex and unequal behavioral and social influences on the individual leading to unequal access and beyond to unequal participation in society based on the differential access. UTAUT stresses the individual’s capabilities and environment in confronting questions of use. It would apply to adoption if the use were first-time use. UTAUT outcomes go beyond the stage of access or adoption to use behavior. SATUM is less concerned with the immediate circumstances of the adoption or use decision or with the innovation features, and rather is focused on the dimensions of society, economy, infrastructure, societal openness, and social capital. It is more flexible than the others on unit of analysis.

The four theories are also compared on types of methodologies employed, based on sample sizes available. For all the theories, variants on regression analysis are often employed. For Van Dijk’s theory and UTAUT, SEM has been widely used, although subject to sample sizes of 100 or more respondents. For SATUM, locational methodologies of spatial cluster analysis and spatial autocorrelation can complement regression analysis. SEM so far has not been applied for this theory, due to limited understanding of how spatial referencing can take place.

These major findings and other details in the analysis answer the research question to identify the leading features of the four models and to understand their pros and cons. Further research and empirical testing is required to evaluate appropriateness of these four models to explain adoption and diffusion of technologies in myriad settings [18].

8. References

Table 1. Comparison of Features of Four Theories

<table>
<thead>
<tr>
<th>Comparison Feature</th>
<th>ADT</th>
<th>van Dijk’s Theory</th>
<th>UTAUT</th>
<th>SATUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical feature</td>
<td>innovations, digital divide, technology use</td>
<td>digital divide</td>
<td>digital divide, socio-economic, economic, infrastructure, societal openness, innovation, social capital</td>
<td></td>
</tr>
<tr>
<td>Independent factors</td>
<td>innovation characteristics, communications, social system, time</td>
<td>positional, personal, resources, technology, access</td>
<td>ease of use, experience, performance expectancy, effort expectancy, social influence, facilitating conditions</td>
<td></td>
</tr>
<tr>
<td>Outcome factors</td>
<td>adoption and diffusion of innovations</td>
<td>participation in society from ICT access</td>
<td>use behavior</td>
<td>utilization of ICTs</td>
</tr>
<tr>
<td>Units of analysis</td>
<td>individual, household</td>
<td>individuals</td>
<td>individual</td>
<td>indiv., household, city, state, nation</td>
</tr>
<tr>
<td>Spatial component of theory</td>
<td>occasional</td>
<td>part of outcome</td>
<td>none</td>
<td>inherent to theory</td>
</tr>
<tr>
<td>Volume of empirical studies</td>
<td>large</td>
<td>moderate</td>
<td>large</td>
<td>small</td>
</tr>
</tbody>
</table>

Table 2. Alternative Methodologies for the Four Theories

3896
Study Category
Adoption-diffusion Theory: The effects of an individual’s adoption of loyalty service is examined, accounting for distance, billboards, innovators, and radio marketing.
Adoption-diffusion Theory: Mobile and Computer internet access is influenced by proxy variables for Rogers’ ADT stages
van Dijk’s Theory. Emphasis on validating high levels of specialized internet uses yet large inequalities by age, educational background, and gender.
van Dijk’s Theory. Use of government Internet-based digital media services, influenced by social, demographic, and psychological variables
UTAUT, enhanced by moderating demographic factors
SATUM. Internet access, influenced by ethnic isolation, moderated by housing and social interactions
SATUM. County clusters based on digital development, infrastructure, social, and economic factors
SATUM. Use of ICTs influenced by socio-economic variables

Focus Category Units of Analysis
Adoption-diffusion Theory  [3] Event-history model of spatial processes, mapping. 17,600 individual adopters of retail loyalty program
Adoption-diffusion Theory  [2] OLS regression. Full sample size of 1,414 individuals in Japan
van Dijk’s Theory.  [34] Descriptive statistics. 1,490 Dutch Internet users.
van Dijk’s Theory. Use of government Internet-based digital media services, influenced by social, demographic, and psychological variables  [36] Structural equations modeling (AMOS) 1,225 Dutch respondents 18 years and older
UTAUT, enhanced by moderating demographic factors  [18] Structural equation modeling Random sample of 150.
SATUM. Use of ICTs influenced by socio-economic variables  [19] Regression, cluster analysis, spatial autocorrelation 47 prefectures

Table 3. Advantages and Drawbacks of the Four Theories

<table>
<thead>
<tr>
<th>Theory</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADT</td>
<td>Covers broadly technologies extending beyond ICTs, to include engineering, biological and other innovations.</td>
<td>Less elaboration on the particular adoption/diffusion characteristics and development steps of ICTs.</td>
</tr>
<tr>
<td></td>
<td>Hypothesizes the trajectories over time of the A/D of innovations.</td>
<td>The individual adopter is ignored for his/her characteristics such as effort, performance expectations, and facilitating conditions.</td>
</tr>
<tr>
<td></td>
<td>Includes pathways of communication of innovations as an A/D factor.</td>
<td>ADT does not include ICT usage continuums or digital divide as outcomes.</td>
</tr>
<tr>
<td></td>
<td>Considers whether an innovation is present or not, relative to the surrounding society.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attributes of innovations are posited. Geography of the A/D process is considered.</td>
<td></td>
</tr>
<tr>
<td>Van Dijk’s</td>
<td>The complex model was purposefully designed to define the extent of digital divide</td>
<td>The model includes constructs with varied units of analysis possibly confusing empirical study.</td>
</tr>
<tr>
<td></td>
<td>Inequalities are posited to permeate the steps in defining digital divide outcomes.</td>
<td>The model might be less applicable in a society that has greater equality in socio-economic status and resources.</td>
</tr>
<tr>
<td></td>
<td>Personal, positional, and societal characteristics are important constructs in the model.</td>
<td>The full amount of information to operationalize the model is difficult to obtain for large samples.</td>
</tr>
<tr>
<td></td>
<td>Model does take time into account since the feedback model can iterate.</td>
<td>Geography of the digital divide is not considered as a factor leading up to access, but only included afterwards.</td>
</tr>
<tr>
<td></td>
<td>The theory extends beyond access to ICT and considers consequent societal participation.</td>
<td></td>
</tr>
<tr>
<td>UTAUT</td>
<td>The dependent variable of behavioral intention is appropriate for digital divide studies of ICT acceptance and use.</td>
<td>The model does not include ICT access, which one of the common dependent measures of digital divide</td>
</tr>
<tr>
<td></td>
<td>UTAUT model is based on common points in eight technology acceptance theories, so has strong IT literature support.</td>
<td>The model is formulated for ICT use by the individual, so is less relevant for unit of analysis of groups or societal units.</td>
</tr>
<tr>
<td></td>
<td>The model encompasses both individual factors and social factors.</td>
<td>The model is formulated based on the context of high- or mid-range economies, but is less relevant for poor nations.</td>
</tr>
<tr>
<td></td>
<td>The theory was formulated to explain ICT acceptance and use, but not with specific focus on digital divide</td>
<td>The model does not take into account longitudinal change.</td>
</tr>
<tr>
<td></td>
<td>Data for empirical testing of UTAUT is available by conducting surveys with reasonably sized samples i.e. 75 or more respondents.</td>
<td>Geography of the digital divide is not considered a factor leading to ICT acceptance and use.</td>
</tr>
<tr>
<td>SATUM</td>
<td>The theory was formulated for digital divide analysis and posits the combined effects on ICT access or use determinants across broad social, economic, political, and policy dimensions.</td>
<td>The model does not posit multi-level and/or multi-directional pathways of effect.</td>
</tr>
<tr>
<td></td>
<td>It includes the dimensions of societal openness and social capital which have proven important for digital divide, but are less common.</td>
<td>Multivariate methods such as regression may encounter multi-collinearity or diagnostic problems of correlated residual errors.</td>
</tr>
<tr>
<td></td>
<td>The theory can be applied for varied units of analysis, ranging from individuals to nations.</td>
<td>The model interpretation must be limited to the unit of analysis being employed.</td>
</tr>
<tr>
<td></td>
<td>SATUM includes geographical mapping and testing of spatial auto-correlation, absence of which can lead to spurious findings.</td>
<td>The model does not include the individual-level psychological factors of motivation, behavioral intention, satisfaction, and others.</td>
</tr>
<tr>
<td></td>
<td>For governmental units of analysis, such as nations and states, reliable government data are often readily available.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K-means cluster analysis can be applied and clusters characterized. The model can be applied for longitudinal analysis such as with fixed effects.</td>
<td></td>
</tr>
</tbody>
</table>

Note: ADT refers to Adoption-Diffusion Theory. A/D refers to adoption and diffusion.