Assessing Indiana's E-Readiness in the Development of the Digital Society:

An Exploratory Study

This study seeks to bridge the gaps in research on the relationship between broadband accessibility and human development by assessing the e-readiness of Indiana counties.

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PRIMACY of PLACE

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Summary

For more than two decades, developed economies worldwide have been investing in a strong digital infrastructure. This effort has accompanied significant social and economic development, which ultimately results in a more digitally connected society. A "digital society" is defined as one in which people communicate through electronic means, and connect to government and private sector services through a robust broadband information and communication infrastructure.

Despite investing in technology infrastructure, however, there remains a significant digital divide between and among regions, states, and counties in the United States. This digital divide occurs in places where existing economic and social conditions lag across the domains of income, health, and educational attainment. Using an existing study, which adapted the Human Development Index (HDI) to Indiana, we extend the notion of human development to include technology (Devaraj, Sharma, Hicks, and Faulk, 2014).

This effort combines information on broadband availability to existing measures of human development to form the Human Development & Technology Index (HDTI), and finds significant variation among counties after the technology index is included in HDI. We also find evidence of lower HDI, Technology Index, and HDTI in rural Indiana, which should be cause for statewide concern. This study will contribute to assessing the e-readiness for social and economic development in Indiana, and to improving our understanding of how digital access interacts with other measures of human development in the wellbeing of households and communities.

Introduction

Over the past two decades, the digital revolution has dramatically changed our lives. Digital access harnesses the immense potential of information and communication technologies for social and economic development across nations, states, and local communities. However, even in highly developed nations there remains a divide between those with access to these technologies and those without or with inadequate access to them. In the US alone, as many as 23 million households may not have access to broadband internet services, a prerequisite for accessing a host of internet-enabled services from private sector commerce to educational programs. This is important because broadband connectivity is not only imperative for connecting to the network world, but it has also become an important factor in social inclusion.

As the internet has become more essential to everyday life, it is increasingly important to assess the broadband connectivity of households. While it is evident that the digital divide between the information "haves" and "have-nots," does exist, even in a country like the United States, to date there has been no national-level research that connects varying levels of broadband connectivity to other measures of human development at the county level.

This study seeks to bridge these gaps by assessing the e-readiness of Indiana counties. We do this by superimposing a "Technology Index" on HDI and providing a map of both human development (HDI) and e-readiness. This study also builds off several previous studies that assessed the disparity of HDI across Indiana's 92 counties in order to examine how internet speed and telecommunication access impacts the HDI ranking landscape of these counties.

This paper is organized into four sections. We first discuss the characteristics of the new internet-based digital society and the foundations of e-readiness before we turn our attention to a methods section in which we describe a conceptual framework to measure e-readiness. In the data analysis section, we provide the comparative ranking of Indiana counties after the Technology Index is superimposed on HDI. We conclude by discussing policy implications of e-readiness for Indiana counties and future research. We intend that this study will contribute to the assessment of e-readiness for social and economic development in Indiana.

E-Readiness for the Internet-Based Digital Society

The use of the internet has changed the world in the last quarter century. Individuals across the globe are increasingly interconnected through various internet-enabled devices. Mobile phones, wearable gadgets, laptops, PDS, and other internet devices are changing the fabric of social and economic development. Digital connectivity is creating new innovations and service delivery in education, healthcare, entertainment, business, and government services. This level of connectivity is the basis of our new digital society.

The digital society is defined as a society that relies on information and communication infrastructure, particularly broadband connectivity, to communicate and receive a broad range of services electronically. Ensuring quality access to the internet and other broadband services is essential in a digital society as people and households regularly transact with businesses, governments, and other households electronically. As such, it is important to assess the capacity, quality, reliability, and affordability of broadband connectivity for engagement with governments and others in terms of e-readiness.

E-readiness is an important tool to assess government policies for social and economic development, and, importantly, for the creation of an internet-based digital society. E-readiness can also be used to highlight the digital divide across counties, states, and nations. There are several factors used to measure e-readiness, including access to an internet service provider, and the broader "Networked Readiness Index" (NRI), an index of more than 60 variables, such as market conditions, political and technology infrastructure, education level of individuals, the level of e-commerce or e-government services.

Broadband has changed the scope and location of economic activity of households, businesses, and governments (Burton and Hicks, 2005). In this study we are only looking at households, which are grouped according to their level of broadband connectivity: 200 Kbps at any direction, or 10 Mbps downstream and 1 Mbps upstream.

The quality of broadband connectivity is important to households for a variety of reasons. It not only creates channels of communication with the network world, but also impacts access to government websites, documents, licenses and tax records, entertainment, healthcare, education, economic development, and social inclusion. In turn, household connectivity is important for promoting open governance, transparency, and the increased participation of citizens in democratic governance. A strong broadband connectivity rate can also generate positive externalities in sociocultural enrichment, empowerment, and political engagement (Katz, 2012).

In the modern economy, broadband connectivity to high-speed internet is increasingly important in accessing public services, commerce, and public education. According to the technologist and internet experts, the broadband internet service should have download speeds of at least 3 Mbps for receiving these services effectively. These speeds allow citizen to tap e-government services and to participate in civic life more effectively with greater ease.[1]

A 2016 report by the FCC, however, finds that 10 percent of the population in the US still lacks access to high-speed broadband, and there is a significant disparity in high-speed broadband access between rural and urban populations. Thirty-nine percent of the population in rural areas lacks access to high-speed broadband, whereas only 4 percent in urban areas do.[2] The broadband adoption rates are, however, similar across rural and urban places (28 versus 30 percent, respectively). Around 41 percent schools in the country still lack the FCC's short-term goal of having 100 Mbps per 1000 students/staff, and a 2013 report finds that the current broadband infrastructure in school is not adequate to deliver effective education.[3]

Current Study

Our previous study used the Human Development Index (HDI) to assess the disparity in HDI across the 92 counties in Indiana. The currenty study is an extension of that, and introduces technology to assess the development conditions across counties. The Technology Index measures internet access connections per 1,000 households over varying upload and download speeds and the share of population with access to internet. We combine this index to form Human Development Technology Index (HDTI).

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1. See https://speedmatters.org/e_government_civic_participation

2. See https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report

3. See http://www.setda.org/wp-content/uploads/2013/09/SETDA_BroadbandImperative_ May20Final.pdf

Data and Methods

Similar to the analysis made in Devaraj, Sharma, Hicks, and Faulk (2014), we first replicate the construction of health, education, and living standard indices with updated data to form the Human Development Index. Devaraj et al. (2014) extends a modified American Human Development Index (Measure of America, 2010) by adjusting the outliers of individual dimension and follows Anand and Sen (1993) method of normalizing the indices. The detailed methodology of Human Development Index are presented in Devaraj, et al. (2014) and subsequently in Devaraj et al. (2015). We briefly summarize the methodology below.

The individual dimensions (and their respective indicators) are normalized as:

$$\text{Index}_{ij} = \frac{X_{ij} - \min_{\text{of 92 counties}} \{X_i\}}{\min_{\text{of 92 counties}} \{X_i\} - \min_{\text{of 92 counties}} \{X_i\}} \times 100 \quad (1)$$

…where *i* is the individual dimensions of HDI – health, education and living standards – and *j* is the Indiana county.

Each of the three dimensions are calculated by taking the geometric mean of their normalized indicators and then further normalizing it to a scale from 1 to 100, with 100 being the most ideal.

Health, Education, & Living Standards Dimensions

Each dimension of the HDI consists of two normalized indicators:

- **Health Dimension:** average life expectancy (Healthdata, 2010) and years of potential life gained (County Health Rankings, 2016 and from authors' computations)
- **Education Dimension:** share of population enrolled in a high school or more (ACS, 2015) and share of population with a high school degree or more (ACS, 2015)
- **Living Standards Dimension:** log of per-capita income (BEA, 2015) and average monthly earnings (QWI, 2015)

Human Development Dimension

We then obtain the human development dimension by taking the geometric mean of these three dimensions:

$$\text{Human development dimension}_j = \sqrt[3]{\text{Health index}_j \times \text{Education index}_j \times \text{Living standards index}_j} \quad (2)$$

We further normalize this human development dimension as in *Equation (1)*.

Technology Dimension

To construct the Technology Index, we use three indicators:

- Residential fixed high-speed connections with over 200 Kbps in at least one direction per 1,000 households (FCC, 2015)
- Residential fixed high-speed connections with at least 10 Mbps downstream and at least 1 Mbps upstream per 1,000 households (FCC, 2015)
- Share of population with access to fixed advanced telecommunications capability (FCC, 2014)

These three indicators are individually normalized across 92 counties in a scale of 0 to 100, with 100 being the county with the most ideal technology dimension and 0 being the county with the least ideal technology dimension for that indicator. The technology dimension was calculated by taking the geometric mean of all three indicator indexes, and then normalizing it.

$$\text{Technology dimension}_j = \sqrt[3]{\text{High speed 200 Kbps}_j \times \text{High speed 10 Mbps down \& 1 Mbps up}_j \times \text{Share of population with access}_j} \quad (3)$$

Aggregate Human Development Technology Dimension

We then estimated the geometric mean of all four indices – health, education, living standards and technology – to form our aggregate human development dimension:

$$\text{Human development technology dimension}_j = \sqrt[4]{\text{Health index}_j \times \text{Education index}_j \times \text{Living standards index}_j \times \text{Technology index}_j} \quad (4)$$

We further normalize this human development technology dimension as in *Equation (1)* to form the Human Development Technology Index (HDTI).

Figure 1. Health Index

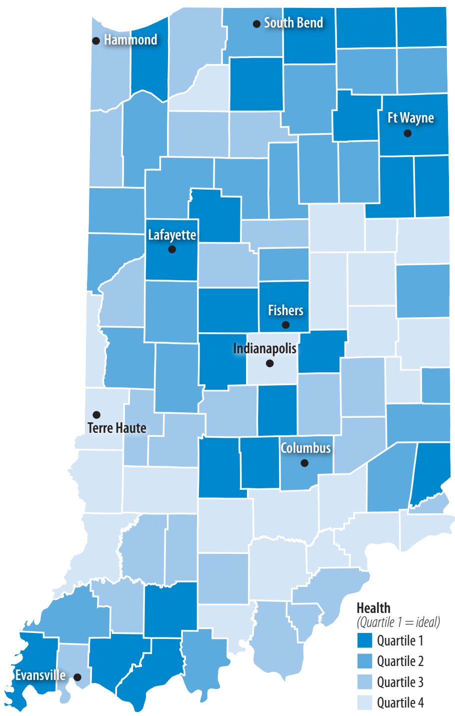


Figure 2. Education Index

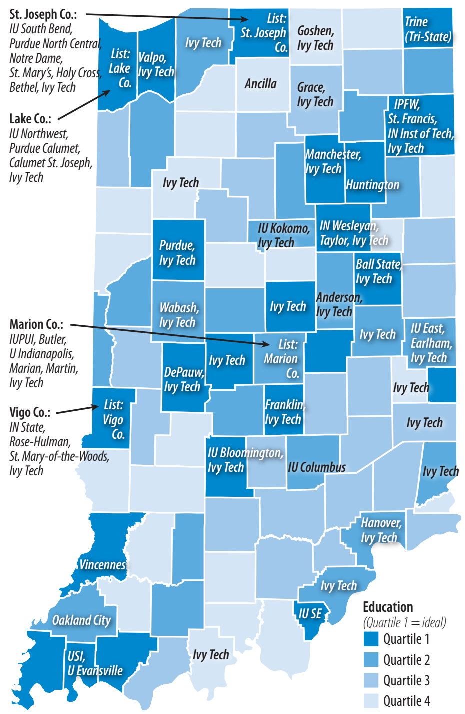
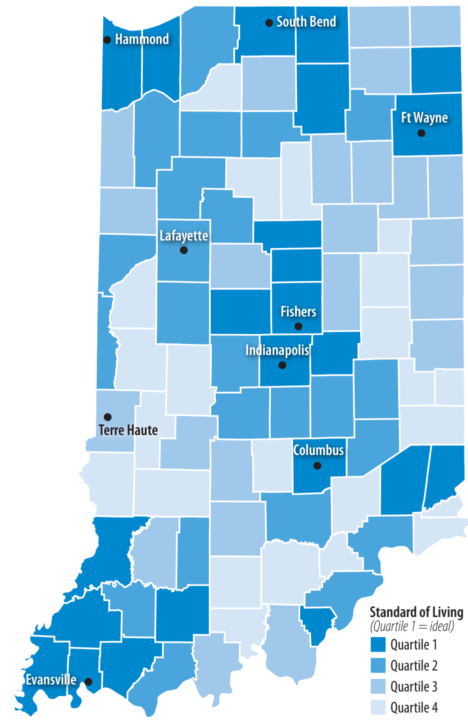


Figure 3. Living Standards Index



Results

Figures 1 through 3 show the health, education, and living standards indices (respectively) for all 92 counties in Indiana. *Figures 4 through 6* show the HDI, Technology Index, and HDTI (respecitively) across Indiana. The change in HDI by the inclusion of the Technology Index is shown in *Figure 7*, and, finally, *Figures 8 through 11* look specifically at differences in these indices across rural and urban counties.

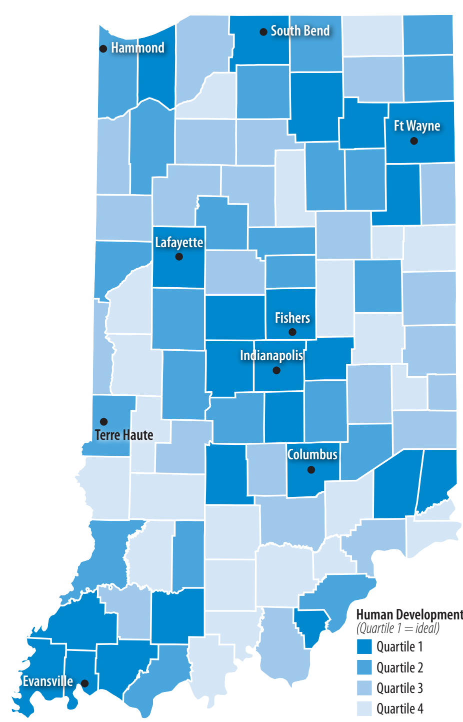
Counties with the highest health index (*Figure 1*) were Hamilton, Hendricks, Monroe, Boone, and Steuben. The counties with lowest health index were Scott, Starke, Fayette, Washington, and Sullivan. A clear pattern that emerges from this map is that the degree of rurality of a county affects its health index, with rural counties scoring in the higher quartiles. This is not all together surprising, as rural residents struggle to receive adequate health care (Berry, 2014), and life expectancy is not only lower in rural counties, but it has been decreasing in recent years (Dwyer-Lindgren, et al., 2016; Xu, et al., 2016).

In general, counties that boost a two-year or four-year college institution (mapped in italics in *Figure 2*) score higher on the education index (in Quartiles 1 and 2). Additionally, as with the health outcomes, educational attainment is closely linked to the level of rurality of a county (Byun, Meece, and Irvin, 2012; Roscigno and Crowle, 2001).

Hamilton, Boone, Marion, Kosciusko, and Posey counties score the highest in the living standards index (*Figure 3*), whereas Switzerland, Ohio, Starke, Parke, and Crawford counties had the lowest living standards. Here again, we see a correlation between rurality and the standard of living measures of the HDI, but for the most part the top and bottom five counties in the living standards index are different than those in the health index.

When the previous indices are combined into the Human Development Index (*Figure 4*), we continue to see some counties that have been on the top/bottom five lists for all the indices, while other counties show up for the first time. The top five counties in the HDI are Hamiton, Monroe, Tippecanoe, Boone, and Porter. The bottom five counties are Scott, Switzerland, LaGrange, Ohio, and Starke. As would be expected from the previous maps,

Figure 4. Human Development Index



we can see that the most urban and surrounding counties have the highest HDI, whereas the rural counties had the lowest.

In terms of the Technology Index (*Figure 5*), Hamilton, Hancock, Floyd, Porter, and Clark counties rate the highest, and Crawford, Switzerland, LaGrange, Union, and Pulaski counties rate the loweset. Although we continue to see urban places ranking higher as compared to rural places, there is relatively little overlap in the top/bottom counties between the Technology Index maps and the previous maps.

When we combine the Technology Index with the HDI to form HDTI (*Figure 6*), we see that the top five counties remain the same – Hamilton, Tippecanoe, Monroe, Boone, and Porter counties – but the bottom five – Switzerland, LaGrange, Crawford, Scott, and Ohio counties – somewhat differ between the HDI and the HDTI. Again, a strong urban/rural story emerges from this map.

Difference in Rankings

Importantly, the Technology Index offers a way to view access to technology in the context of other dimensions of human development. However, we would like to observe how technology interacts with these other features of development and whether access to technology mitigates or exacerbates other human development measures.

To do this, we now test to see if there is difference in county rankings between HDTI and HDI. *Figure 7* shows the difference in rankings due to technology among 92 counties. The counties in orange saw their HDI decline because of relatively lower technology index. The counties in blue saw their HDI increase owing to relative technology scores. The counties in gray did not change their rankings.

We see that many urban cities and their surrounding counties improved their HDI after the inclusion of the Technology Index, whereas the HDI of rural counties worsened after considering their respective Technology Index. This suggests that inclusion of technology access exacerbates, rather than mitigates, measures of the HDI. This is problematic in the sense that the deployment of technology would tend to increase, rather than mitigate, inequality in standard of living measures. Thus, it is helpful to understand how the HDTI is affected across other margins, such as urbanization.

Given that the deployment of telecommunications faces significant fixed costs across all geographies, the population density and topography play a significant role in the feasible construction of broadband networks. Thus, it is likely that urban places will have greater technology access than less densely populated places. This argues for a closer examination of rural and urban deployment of technology and its effect on living standards.

> *We see that many urban cities and their surrounding counties improved their Human Development Index scores after including the Technology Index.*

Figure 5. Technology Index

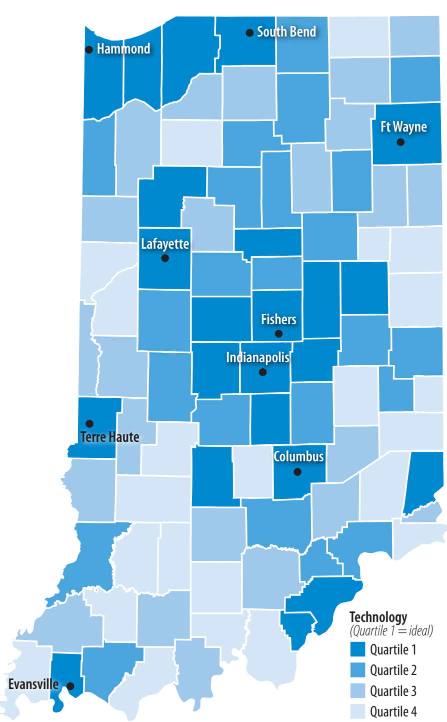


Figure 6. Human Development & Technology Index

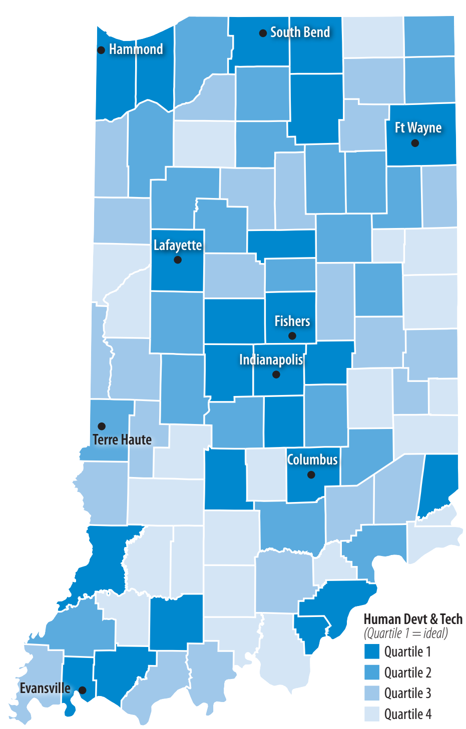


Figure 7. Changes to HDI Measures Due to Technology

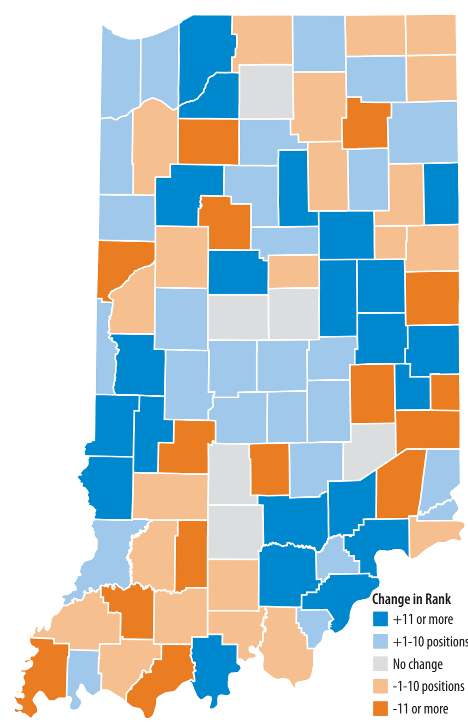


Figure 8. HDTI with Rural-Urban Code

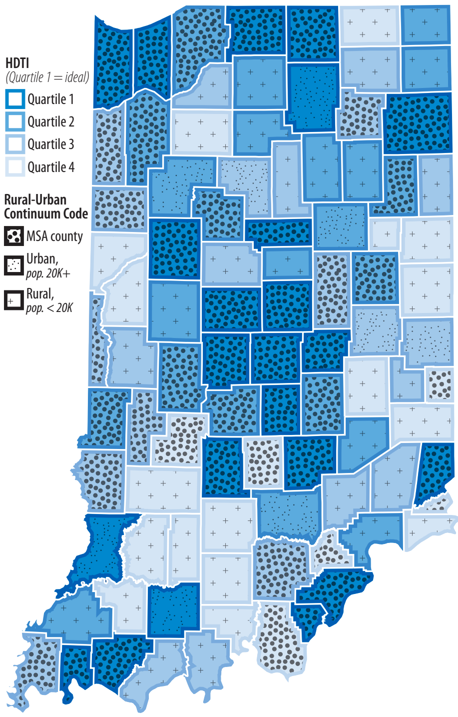


Figure 9. RUCC and Technology Index Relationship

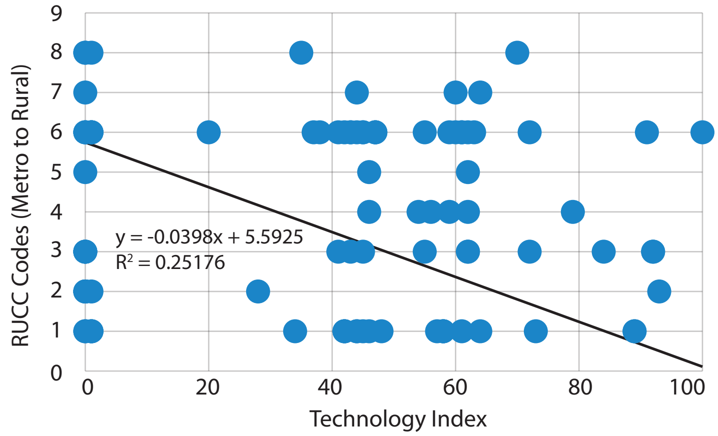


Figure 10. RUCC and Human Development Index Relationship

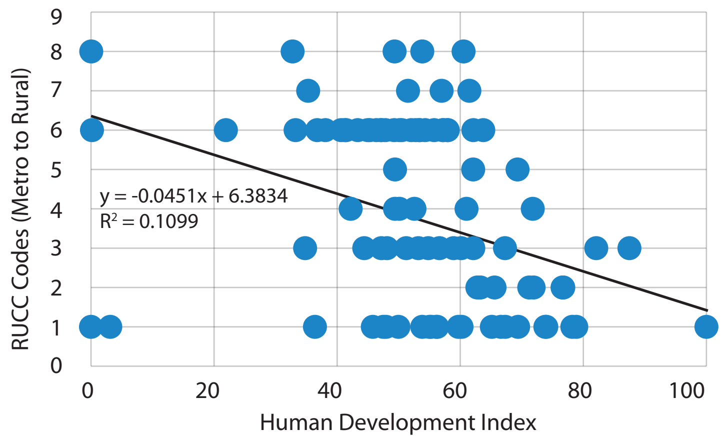
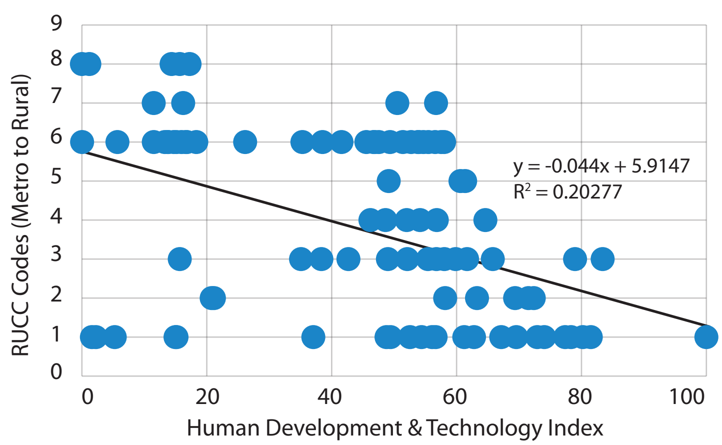


Figure 11. RUCC and Human Development & Technology Index Relationship



Rural Classifications & Index Scores

We use the USDA's rural-urban continuum codes (RUCCs) to separate all 92 Indiana counties. *Figure 8* shows the HDTI by each county's RUCC.

Visually, *Figure 8* plainly shows a high correlation between HDTI and the degree of urbanization in Indiana.

We now test the association between the HDI, Technology Index and HDTI against the RUCCs. *Figures 9 through 11* show the scatter plots of the associations with RUCCs on the vertical axis. Very generally, the higher the RUCC, the more rural the county is. The indices are shown on the horizontal axis. We find that for all three plots, the higher the rurality of a county, the lower the HDI, Technology Index, and HDTI.

Again, all three of these graphics depict the effect of urban places on our measures of the standard of living. RUCCs are negatively correlated with HDI, Technology Index, and HDTI. A chief conclusion from this analysis is that technology access appears to exacerbate, not mitigate, inequality measures used in the HDI, particularly in terms of rural/urban inequality.

> *Large urban centers and their surrounding counties are better off in terms of HDI, and that advantage is enhanced by technological access and quality.*

Summary and Discussion

Strong broadband connectivity provides a vehicle to connect households to businesses to each other, and households and businesses to the wider world. An abundance of literature documents the contribution of effective broadband connectivity to economic and social development in communities. Unfortunately, inequalities in broadband connectivity, most obvious across urban and rural areas, appears to accentuate inequality, rather than mitigate it. This phenomenon is called the digital divide, and remains a troubling concern of policymakers and researchers worldwide.

By superimposing the "Technology Index" on HDI to form Human Development & Technology Index (HDTI), the findings of this study indicate that there is a wide digital disparity within Indiana. Despite having an already low HDI, rural areas are worse off when their existing technology access and quality is considered in our model of human development.

This work suggests technology, especially broadband access, acts to increase regional inequalities. This is not a new finding, but it does force consideration of both policy and research aimed at better understanding the role technology change in isolating rural communities and exacerbating regional inequalities.

Inequalities in broadband connectivity, most obviously across urban and rural areas, appears to accentuate inequality rather than mitigate it.

Credits

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The RUPRI Center for State Policy at Ball State is a join initiative between Ball State's Indiana Communities Institute and the University of Iowa's Rural Policy Research Institute, which leads a national network of academics. The Center for State Policy examines the unique positions of rural communities across the nation and provides policy recommendations at state and federal levels.

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