



Research & Policy INsights

Digital Divide in the U.S.

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Advancing Collaboration : Energizing Regions

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■ **Executive Summary**

The digital divide is a complex issue. This report attempts to define and measure the digital divide in the U.S. and seeks to understand its impact on demographics, jobs, and establishment profiles of urban and rural counties.

Digital Divide Statistics

- A Digital Divide Index (DDI) is introduced consisting of two components: broadband infrastructure/adoption and socioeconomic characteristics known to impact technology adoption.
- In 2015, about 4.3 percent of Americans resided in counties where the digital divide was higher and of these, 57.7 percent lived in rural counties (see Figure 3).
- As of 2015, 10.1 percent or about 31 million Americans did not have access to fixed broadband of at least 25 Megabits per second (Mbps) download and three Mbps upload. Concentrations of counties where 50 percent or more of their population did not have access to 25/3 can be seen across the country (see Figure 1).
- Using DDI quartiles, the majority of counties with the lowest digital divide concentrated in the northeast, the west coast, and urban pockets throughout the country (see Figure 2).
- Counties with the highest digital divide lost total and prime working age (25 to 54) population between 2010 and 2015 (see Figure 4). Likewise, the prime working age labor force participation rate was lowest in counties with a higher digital divide (see Figure 5).

Impacts of the Digital Divide

- Job and establishment growth between 2010 and 2015 was substantially lower in counties with the highest digital divide; establishments with paid employees declined in counties with the highest digital divide while establishments with no employees barely grew (see Figures 6 & 7).
- Digital economy industries—one of the fastest growing group of industries in the nation—and associated jobs increased overall and across all DDI quartiles between 2010 and 2015 (see Figure 8).
- Digital economy establishments—of which 57 percent were nonemployers—increased in the nation and across all digital divide categories. In fact, the largest percent change in digital economy establishments between 2010 and 2015 took place in counties with the highest digital divide (see Figure 9).

Policy Recommendations

- Economic and community development efforts need to be refined to target and support digital economy entrepreneurs that are emerging throughout the nation. Robust strategies should not only focus on updating broadband infrastructure, but also on increasing awareness and digital literacy knowledge to effectively leverage and maximize these technologies.
- Collaboration among key local and regional assets—schools, libraries, nonprofits, Extension Services, local economic development organizations, regional planning commissions, think tanks, faith-based among others—should be strengthened. This will ensure that local and regional resources will be working in tandem to tackle the digital divide problem in high need areas of the country.

■ Introduction

Digital technologies and applications are transforming the way we access information, search/apply and work, engage with the government, communicate with friends and relatives, obtain quality education, and access quality health care. In other words, digital applications are affecting our quality of life in a variety of ways. The assumption is that, with access (including affordability) to the technology (specifically broadband) and knowledge to leverage these digital applications, society benefits.

Academic research has documented the impact of broadband in economic development, civic engagement, telehealth, and agriculture, among other

sectors¹. However, what happens if the access and/or knowledge are lacking? This digital divide does not bode well in an age where information and computing technologies are the primary means of producing content and knowledge². In that case, businesses, individuals, governments, and communities trail behind in this rapidly changing landscape, leading to a widening of the digital divide.

The digital divide is between those that have access, can afford, and apply knowledge to leverage the technology to improve their quality of life versus those that do not have access, cannot afford, or lack knowledge. The digital divide is the critical issue of the 21st century.

This report attempts to measure the digital divide with an innovative measure called the Digital Divide Index (DDI). The DDI examines the impact on demographics, jobs, and establishment trends of the U.S. The DDI is a descriptive and pragmatic tool, designed to promote awareness and more importantly, jumpstart critical discussions of ways to address the issues it raises.



Measuring the Digital Divide

Although multiple measurements of the digital divide exist—DIDIX, Network Readiness Index, and the Digital Access Index, to name a few—they tend to focus on national trends or on neighborhoods situated in metropolitan areas³. Some efforts to explore the issue at the county level have begun, including a recent study that defined the digital divide by examining three broadband-related indicators and linking it with a human development index⁴.

¹ (Gallardo, Whitacre, & Grant, 2018)

² (Rogers, 2016)

³ (Tomer, Kneebone, & Shivaram, 2017)

⁴ (Devaraj, Sharma, Wornell, & Hicks, 2017)

This report looks at the digital divide at the census tract (neighborhood) and county-level. The DDI has two components. The first includes broadband infrastructure and adoption indicators, such as access to fixed broadband of at least 25 Megabits per second (Mbps) downstream and three Mbps upstream (25/3 for short), residential connections of at least 10 Mbps down and 1 Mbps up, and average advertised download/upload speeds. The second component incorporates socioeconomic characteristics known to affect technology adoption such as age, poverty, educational attainment, and any kind of disability⁵.

Together, these two components produce an overall DDI score. The scores of the overall DDI, as well as the infrastructure/adoption and socioeconomic components, were normalized to a 0 to 100 range, where a higher score denotes a higher divide. Table 1 summarizes the DDI variables.

Table 1. DDI Variable Summary

Description	DDI Component	Source
Percent Population without access to fixed 25/3	Infrastructure/Adoption	FCC Form 477
Residential connections of at least 10/1	Infrastructure/Adoption	FCC Form 477
Average Maximum Advertised Download Speed	Infrastructure/Adoption	FCC Form 477
Average Maximum Advertised Upload Speed	Infrastructure/Adoption	FCC Form 477
Percent Population Ages 65 and over	Socioeconomic	ACS 5-Year
Individual Poverty Rate	Socioeconomic	ACS 5-Year
Percent Pop. 25 and over with less than high school	Socioeconomic	ACS 5-Year
Percent Noninstitutionalized population with disabilities	Socioeconomic	ACS 5-Year

The DDI produces three different scores that can help guide strategic decisions by local leaders. For example, if a particular county has a substantially larger infrastructure/adoption score compared to the socioeconomic score, efforts should focus on upgrading the broadband infrastructure. On the other hand, if a particular geography has a substantially larger socioeconomic score compared to the infrastructure/adoption score, efforts should target improving digital literacy. For more information on the methodology of the DDI please visit <http://pcrd.purdue.edu/ddi>⁶.

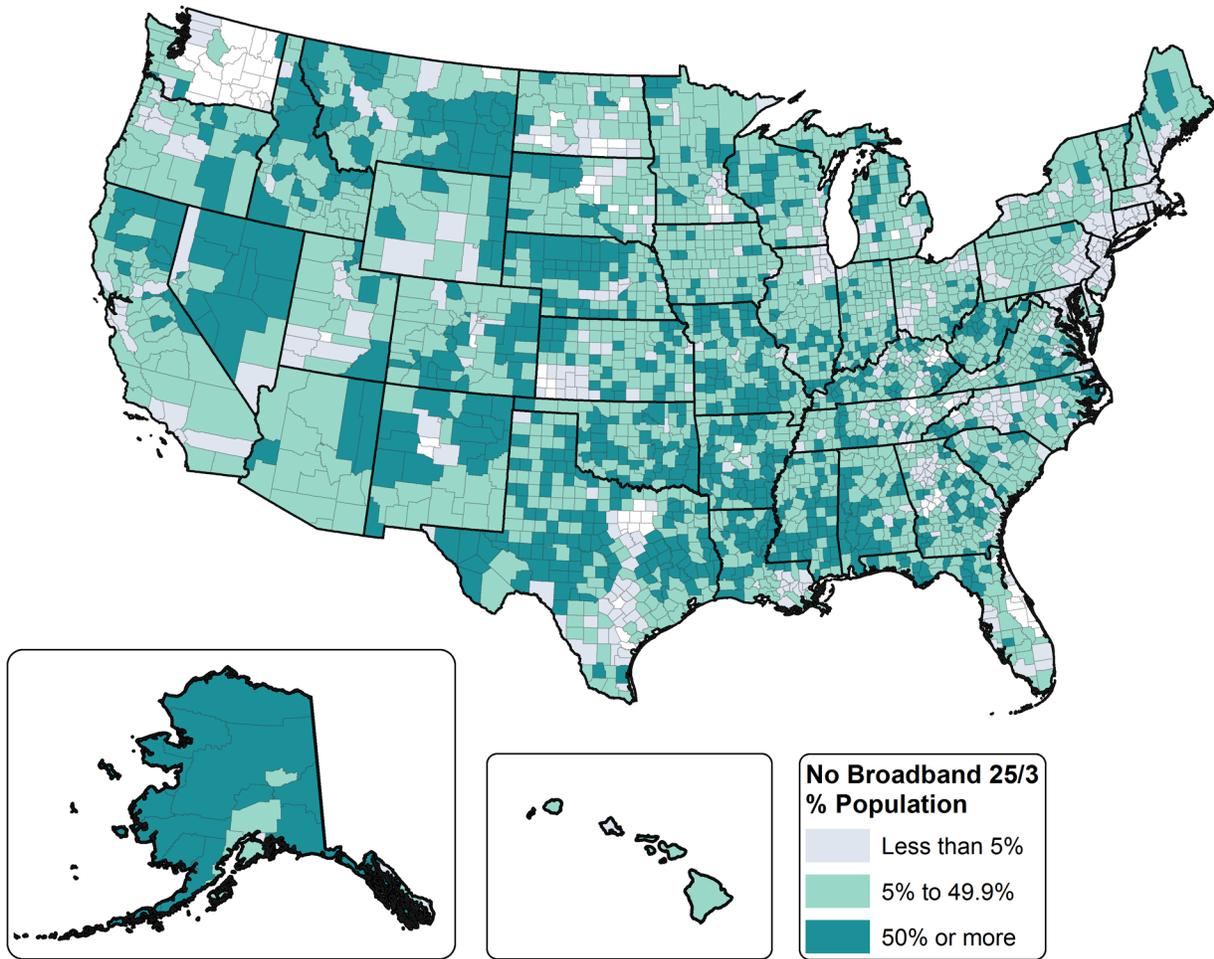
Geography of the Digital Divide in the U.S.

Before mapping the DDI, it is useful to look at the percent of population without access to 25/3 fixed broadband, as of 2015. While the digital divide is more complex than broadband access only, it does help identify areas that are behind in broadband infrastructure. Figure 1 shows counties in the country, based on their percent of total population, lacking access to 25/3 fixed broadband.

⁵ (Perrin & Duggan, 2015)
⁶ Also available are printer-friendly DDI profiles for each Indiana county

Figure 1

Percent 2010 Population without access to fixed 25/3 broadband



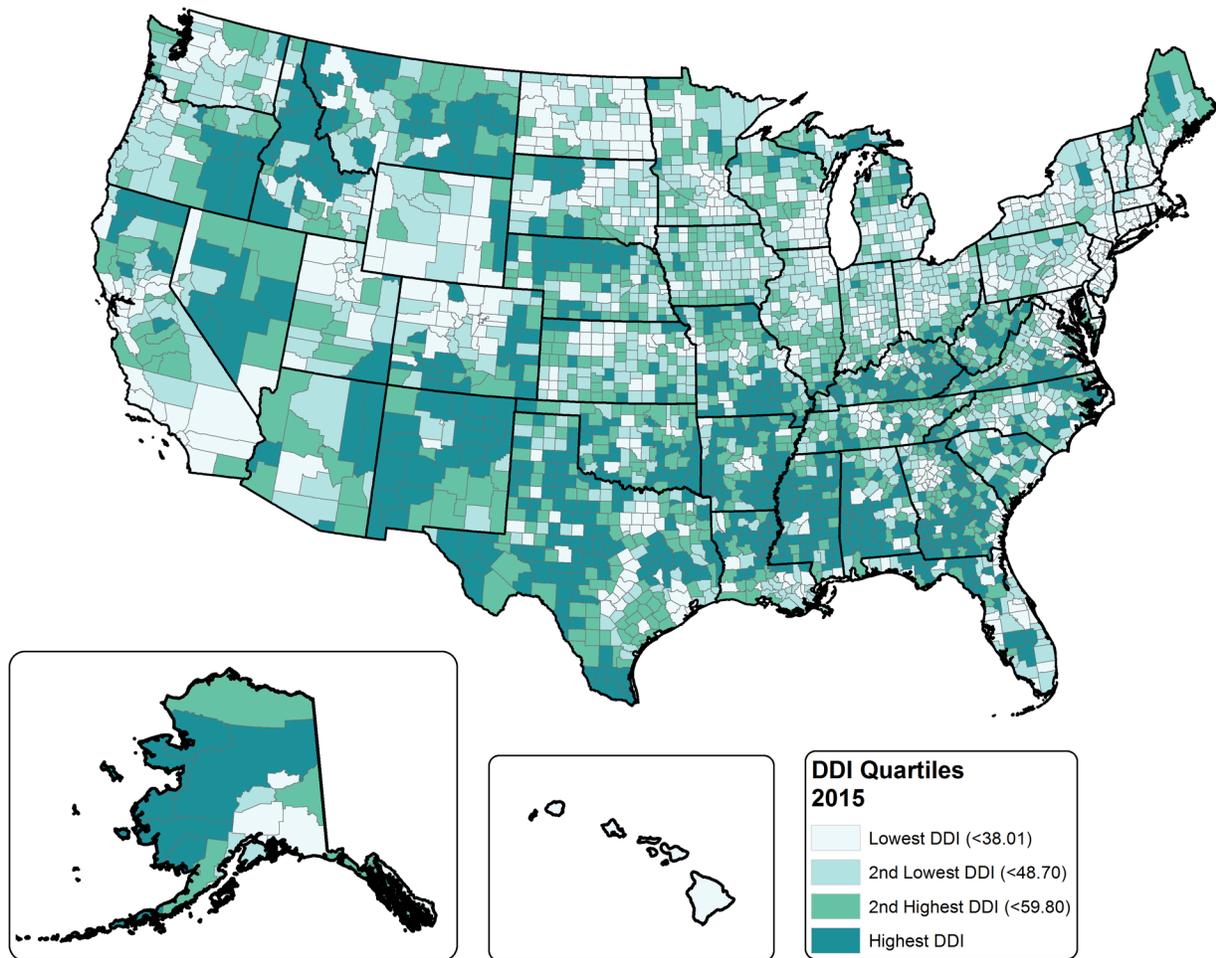
Source: Purdue Center for Regional Development; FCC Form 477 December 2015 v2
Note: Alaska and Hawaii not at scale

As seen in Figure 1, there are pockets of counties where 95 percent of their population had access to fixed 25/3 (gray color) while other counties had 50 percent or more of their population without access (dark color). When all is said and done, about 10.1 percent (or 31.3 million of Americans) lacked access to fixed 25/3 as of 2015.

Shifting gears from access only to the DDI, all counties in the nation were divided into four equal groups or quartiles based on their DDI score. The DDI score for each county is calculated based on the average of all other counties in the nation. Figure 2 shows counties by DDI quartile.

Figure 2

U.S. Counties by DDI Quartiles



Source: Purdue Center for Regional Development DDI
Note: Alaska and Hawaii not at scale

Figure 2 reveals that the majority of counties with the lowest digital divide or DDI score are concentrated in the northeast, west coast, and mostly urban areas. On the other hand, counties where the divide is higher are shown as dark and include a good part of Appalachia, the central southeast, New Mexico, and eastern Oregon areas.

Another useful way to examine the DDI is on the metropolitan status of counties. As such, we divided the nation's counties in three categories: metropolitan, small city (micropolitan), and rural (noncore)⁷. Table 2 and Figure 3 show the 2015 population and percent population by county type and DDI quartile.

⁷ (USDA Economic Research Service, 2013)

Table 2. 2015 Population by County Type and DDI Quartile

Type	Lowest DDI	% of Total	2nd Lowest DDI	% of Total	2nd Highest DDI	% of Total	Highest DDI	% of Total
Metropolitan	220,429,694	97.1	43,235,900	74.4	7,945,565	36.0	3,156,957	23.1
Small City	5,689,188	2.5	11,007,513	18.9	7,910,296	35.9	2,634,497	19.2
Rural	902,316	0.4	3,879,263	6.7	6,205,649	28.1	7,902,780	57.7
Total	227,021,198	70.7	58,122,676	18.1	22,058,510	6.9	13,694,234	4.3

Source: Purdue Center for Regional Development DDI; Census Bureau

Figure 3. Percent 2015 Population by County Type and DDI Quartile

Source: Purdue Center for Regional Development DDI; Census Bureau

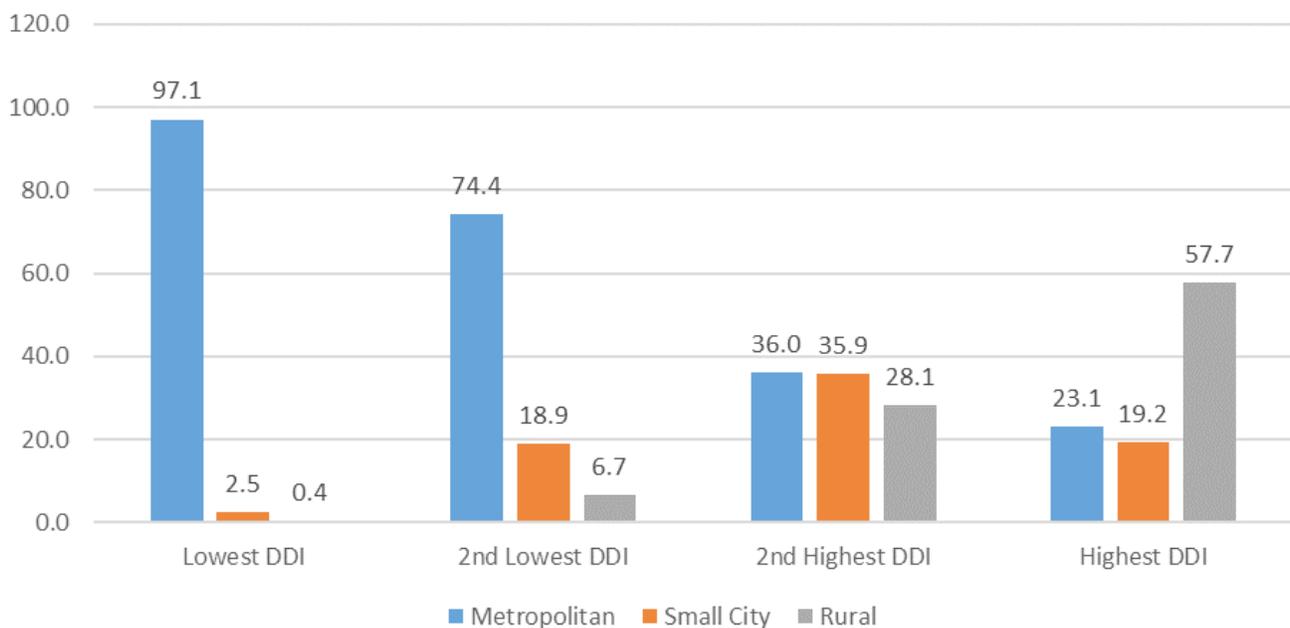


Table 2 and Figure 3 show that while 23.1 percent of the 2015 population with the highest digital divide live in metropolitan counties, 57.7 percent lived in rural counties. On the other hand, 97.1 percent of residents in counties with the lowest digital divide resided in metropolitan areas versus only 0.4 percent in rural counties. Overall, a little over 11 percent of Americans—or 35.7 million Americans—live in counties where the digital divide falls into the two highest quartiles.

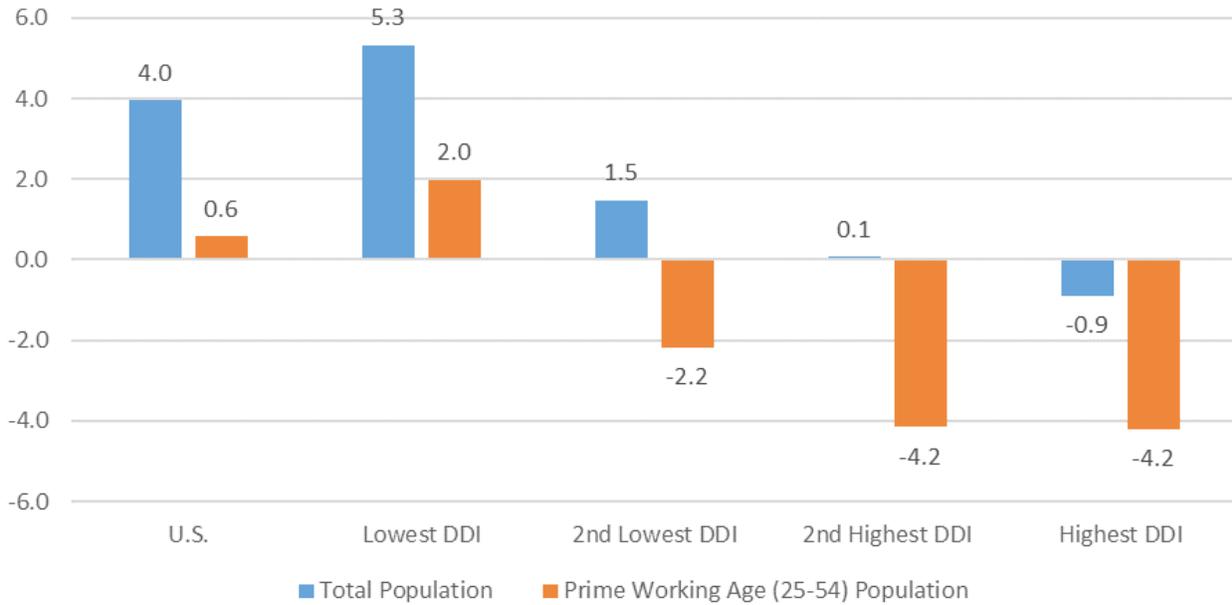
Another trend worth highlighting from Figure 3 is that as the digital divide increases, the proportion of the population living in rural counties increases.

Impact of Digital Divide

What are the impacts of the digital divide on specific socioeconomic indicators, if any? Figure 4 displays the 2010-2015 change in total population as well as the prime working age population (ages 25 to 54) by DDI quartiles.

Figure 4. 2010-2015 Percent Change: Total and Prime Working Age Population by DDI Quartiles

Source: Purdue Center for Regional Development DDI; Census Bureau; ACS 5-Year

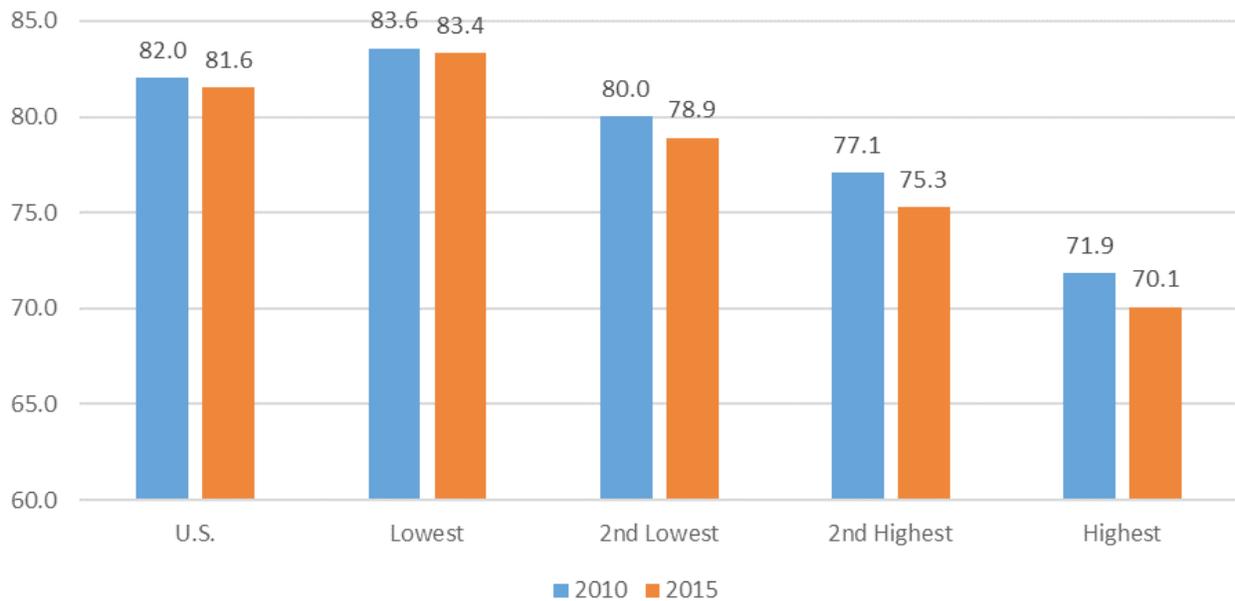


The nation's population grew by 4 percent between 2010 and 2015, from about 308 million to 320 million. However, growth of the prime working age population (0.6 percent) was substantially lower. The group of counties with the highest digital divide suffered population declines, both overall and among people of prime working age. The three groups with the highest DDI lost people of prime working age.

Regarding the labor force participation rate (LFPR) of the prime working age population, Figure 5 shows that counties with a higher digital divide had a lower LFPR in both 2010 and 2015. Worth noting is that the prime working age LFPR decreased overall and in each of the DDI quartiles between 2010 and 2015.

Figure 5. Prime Working Age Labor Force Participation Rate 2010 & 2015

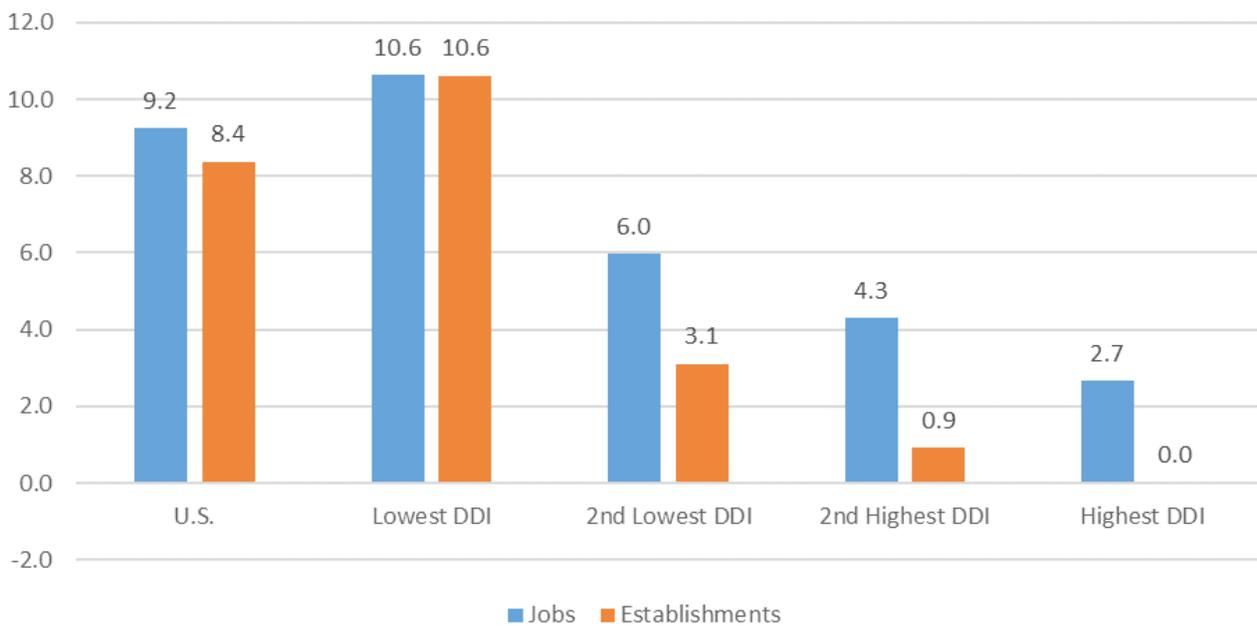
Source: Purdue Center for Regional Development DDI; Census Bureau; ACS 5-Year



Regarding jobs and establishments, Figure 6 shows the percent change between 2010-2015 in total number of jobs and establishments⁸. Again, the trend is clear: as the digital divide increases, the change in jobs and establishments are lower. In fact, no growth in establishments occurs in counties with the highest digital divide, but increases 10.6 percent in counties with the lowest digital divide.

Figure 6. 2010-2015 Percent Change in Jobs and Total Establishments

Source: Purdue Center for Regional Development DDI; EMSI; County Business Patterns; Nonemployer Database

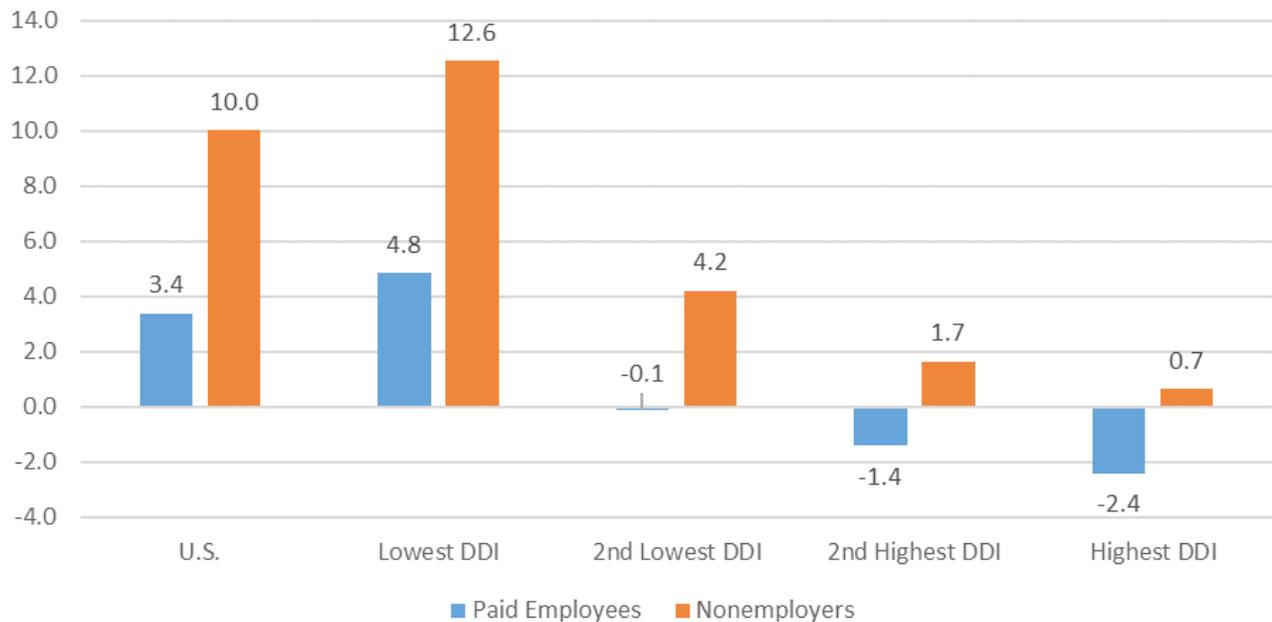


⁸ Establishments include those with paid employees and those denominated nonemployers (paid federal taxes but reported no employees).

Figure 7 highlights the 2010-2015 percent change in establishments by type—those with paid employees and those with no employees—by DDI quartile. The change in establishments with paid employees decreases as the digital divide increases. However, nonemployer establishments increase, though at a slower pace where the divide was highest. In other words, entrepreneurs tend to emerge throughout the nation, but more in counties with the lowest digital divide.

Figure 7. 2010-2015 Percent Change in Establishments with Paid Employees and Nonemployers

Source: Purdue Center for Regional Development DDI; EMSI; County Business Patterns; Nonemployer Database



Aside from distinguishing between paid employees and nonemployers, it is also important to look at establishments by industry type. Recent reports state that a core group of industries with strong ties to the digital age are growing at a faster pace compared to other industries^{9 10 11}. We label these “digital economy” industries¹². Figure 8 shows the 2010-2015 percent change in digital economy establishments and jobs while Table 3 shows the actual numbers.

As shown in Figure 8, digital Economy jobs in the nation increased overall and across all DDI quartiles, with the largest increase—22.5 percent—in counties with the lowest digital divide (as expected). The fact that digital economy job growth in counties with the second lowest DDI is lower compared to those counties with the highest DDI indicates other factors may be at play.

⁹ (Mandel, 2017)

¹⁰ (Muro, Kulkarni, & Hart, 2016)

¹¹ (Siwek, 2015)

¹² Digital economy industries: 454111 Electronic Shopping; 454112 Electronic Auctions; 4931 Warehousing and storage*; 51121 Software Publishers; 51711 Wired Telecommunications Carriers; 51721 Wireless Communications Carriers; 51791 Other Telecommunications; 51821 Data Processing, Hosting, and Related Services; 51913 Internet Publishing and Broadcasting and Web Search Portals; 54151 Computer Systems Design and Related Services

Figure 8. 2010-2015 Percent Change in Digital Economy Jobs and Establishments

Source: Purdue Center for Regional Development DDI; EMSI; County Business Patterns; Nonemployer Database

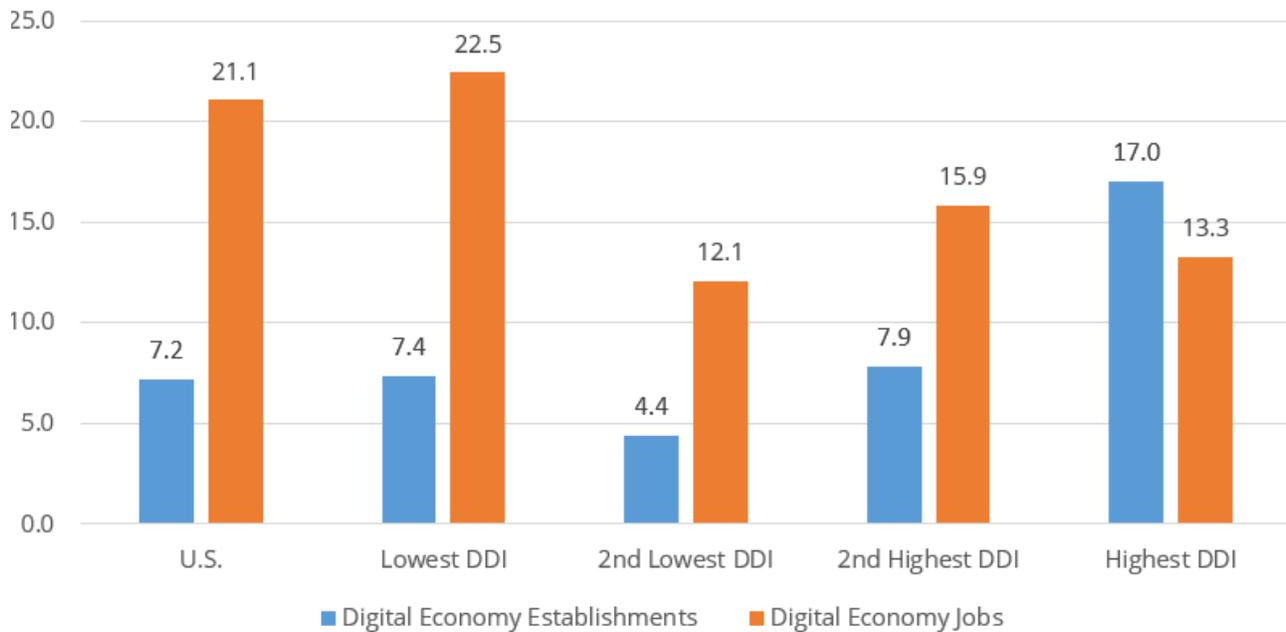


Table 3. 2010, 2015 Digital Economy Jobs and Establishments

Digital Economy	Establishments				Jobs			
	2010	2015	# Ch.	% Ch.	2010	2015	# Ch.	% Ch.
U.S.	576,629	618,039	41,410	7.2	4,387,325	5,313,075	925,749	21.1
Lowest DDI	496,130	532,667	36,537	7.4	3,761,084	4,605,891	844,808	22.5
2nd Lowest DDI	58,766	61,342	2,576	4.4	453,319	508,059	54,740	12.1
2nd Highest DDI	15,324	16,530	1,206	7.9	124,677	144,457	19,781	15.9
Highest DDI	6,409	7,500	1,091	17.0	48,246	54,667	6,421	13.3

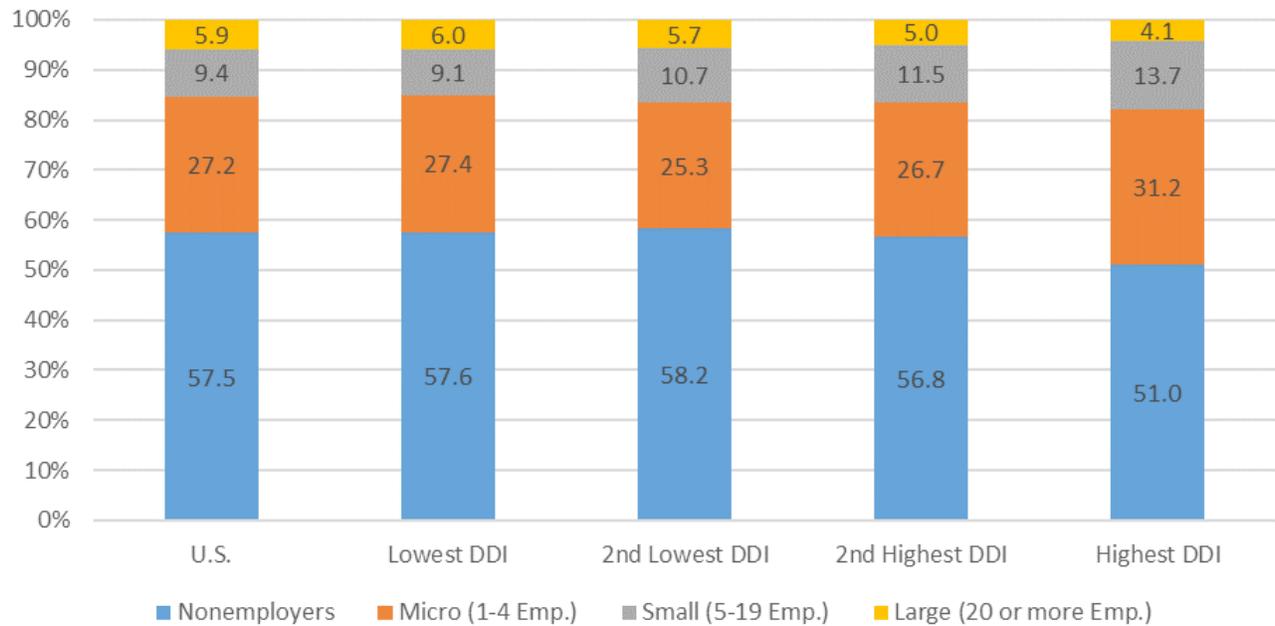
Source: Purdue Center for Regional Development DDI; EMSI; County Business Patterns; Nonemployer Database)

However, something interesting is worth pointing out. While most digital economy establishments increase overall and across DDI quartiles, the largest increase—17.0 percent—occurs in those counties with the highest digital divide. Granted, the base number is lower but establishments in the second highest and highest DDI quartiles increased by about 2,200. While this finding seems counterintuitive and unexpected, perhaps digital economy entrepreneurs may be growing in areas where the digital divide is highest due to the limited availability of jobs. This trend sheds light on an unanticipated characteristic of digital economy-related establishments that future researchers may want to look into.

How is it possible that digital economy establishments have the largest increase in counties with the highest digital divide while losing total and prime working age population (see Figure 4)? Uncovering the exact reasons for this unexpected finding goes beyond the scope of this research, but a helpful first step could be to shed light on the composition of digital economy establishments by number of employees. Results are shown in Figure 9.

Figure 9. Digital Economy Establishments by Size, 2015

Source: Purdue Center for Regional Development DDI; EMSI; County Business Patterns; Nonemployer Database



As shown in Figure 9, more than half of digital economy establishments in the nation in 2015 were constituted of nonemployers while a little more than a quarter had one to four employees. Less than six percent of the establishments had 20 or more employees. This information can partially explain why these establishments grew even though prime working age population decreased. Interesting as well is the fact that the size composition of these establishments is very similar for the nation and across DDI quartiles. In other words, the majority of digital economy establishments are entrepreneurs.

These local entrepreneurs may be strategically leveraging digital platforms for their businesses minimizing costs, increasing efficiency, and reaching new markets. This apparently allows them to “break free” of the otherwise limited labor force and market in their more than likely small communities.

On top of that, they emerged in a context with a high digital divide. If this is the case, what can be done to (1) spur more of these businesses and (2) further sustain them? Answering these questions has large implications for community and economic development policy as discussed in the next and final section.

■ ■ *Conclusions*

As discussed throughout this report, the digital divide is the most critical issue of the 21st century. Efforts must be made to bridge or minimize this divide. Public policy 101 dictates that agreement and measurement of a problem is the crucial first step before any discussion can take place on potential solutions. This report attempts to define and measure the problem through the development and analysis of the DDI. The data analysis captured in this article is intended to jumpstart meaningful conversations in the hope that effective policy solutions can be advanced in a timely fashion.

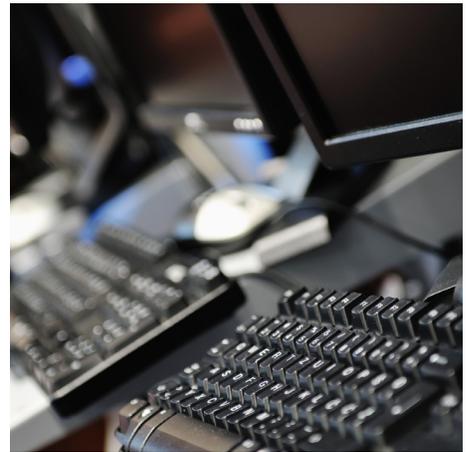
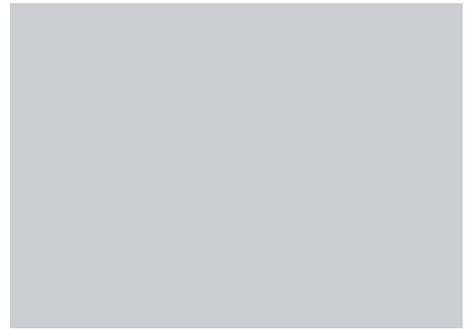
While a relatively lower percent of the country's population resides in counties with the highest digital divide (4.3 percent in 2015), due to commuting patterns and intertwined regional economies, the issue affects the entire nation.

More importantly, economic development strategies should be fine-tuned to target local entrepreneurs and smaller businesses. Although digital economy establishments are indeed emerging in areas with a high digital divide, efforts must be made to support and guide these businesses, facilitating their capacity to not only remain in business but also expand in this highly competitive digital age. If they remain in a high digital divide context, their ability to grow or remain in business will be compromised.

As a thought exercise, consider the following: in 2015, there were about 355,000 digital economy nonemployer establishments in the nation. If half of those created one job over the next 1-2 years, the result would be the addition of approximately 177,000 jobs. More importantly, since these are homegrown businesses, the possibilities of them staying and being active contributors to their communities are much higher.

From a quality of life perspective, reducing the digital divide could bring several additional benefits. Beyond those captured by local businesses, a bridged digital divide could benefit local governments, helping them leverage digital platforms to improve efficiencies and expand their interactions and responsiveness to local residents. Furthermore, it could allow local areas to take advantage of telework, telehealth, and other broadband applications increasing the quality of life.

A coordinated, robust effort should be made to improve broadband infrastructure throughout the country that are on the wrong side of the divide while at the same time increasing digital literacy and know-how among residents, elected officials, and businesses. Existing assets such as libraries, the land-grant university based Extension system, nonprofits, and schools can collaborate to tackle this issue. In the end, the nation will be better poised to reap the benefits of this unfolding digital age.



■ Bibliography

- Devaraj, S., Sharma, S., Wornell, E. J., & Hicks, M. J. (2017). Human Development & Technology in US Counties: Technology Quality & Accessibility Considerations for Policy Makers. Ball State University. Retrieved from <http://projects.cberdata.org/reports/HDTI-US-20171005.pdf>
- Gallardo, R., Whitacre, B., & Grant, A. (2017). Broadband's Impact: A Brief Literature Review. Purdue Center for Regional Development. Retrieved from <https://www.pcrd.purdue.edu/files/media/Broadbands-Impact-Final.pdf>
- Mandel, M. (2017). How Ecommerce Creates Jobs and Reduces Income Inequality. Progressive Policy Institute. Retrieved from http://www.progressivepolicy.org/wp-content/uploads/2017/09/PPI_ECommerceInequality-final.pdf
- Muro, M., Kulkarni, S., & Hart, D. M. (2016). America's advanced industries: New trends. Brookings Institution. Retrieved from <https://www.brookings.edu/research/americas-advanced-industries-new-trends/>
- Perrin, A., & Duggan, M. (2015). Americans' Internet Access: 2000-2015. Pew Research Center. Retrieved from <http://www.pewinternet.org/2015/06/26/americans-internet-access-2000-2015/>
- Rogers, S. (2016). Bridging the 21st Century Digital Divide. *Tech Trends*, 60, 197-199.
- Siwek, S. E. (2015). Measuring the U.S. Internet Sector. Internet Association. Retrieved from <http://internetassociation.org/wp-content/uploads/2015/12/Internet-Association-Measuring-the-US-Internet-Sector-12-10-15.pdf>
- Tomer, A., Kneebone, E., & Shivaram, R. (2017). Signs of Digital Distress. Mapping broadband availability and subscription in American neighborhoods. Brookings Institution. Retrieved from <https://www.brookings.edu/research/signs-of-digital-distress-mapping-broadband-availability/>
- USDA Economic Research Service. (2013). What is Rural? Retrieved from USDA: <https://www.ers.usda.gov/topics/rural-economy-population/rural-classifications/what-is-rural/>



Center for Regional Development
Advancing Collaboration : Energizing Regions

PCRD seeks to pioneer new ideas and strategies that contribute to regional collaboration, innovation and prosperity. Founded in 2005, the Center partners with public, private, nonprofit and philanthropic organizations to identify and enhance the key drivers of innovation in regions across Indiana, the U.S. and beyond. These drivers include a vibrant and inclusive civic leadership, a commitment to collaboration, and the application of advanced data support systems to promote sound decision-making and the pursuit of economic development investments that build on the competitive assets of regions.



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