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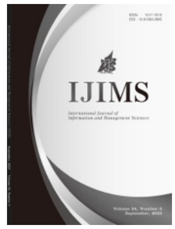

The Pivotal Role of Information and Communication Technology In Shaping US State Economic Development: Manufacturing vs. Non-Manufacturing Sectors

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Keywords

Information and Communication Technology (ICT); US State Economies; Manufacturing; Non-Manufacturing; Economic Development.

Abstract

This paper investigates the impact of Information and Communication Technology (ICT) on the economies of fifty US states, distinguishing between manufacturing and non-manufacturing sectors. Using multivariate time series analysis with data from 2010 to 2020, three modes of ICT—wired high-speed internet (broadband), mobile internet and satellite internet—are examined. This study finds that these ICT modes significantly drive economic growth in both sectors, underscoring the importance of the need for tailored broadband strategies to address geographical disparities. The study also offers policy recommendations for enhancing economic development through targeted ICT investments in both manufacturing and non-manufacturing sectors.

1. Introduction

Information and Communication Technologies (ICT, hereinafter) have significantly disrupted a nation's economy, driven by ICT advancements, major geo-political and geo-economic factors like COVID-19. Assessing ICT's economic impact has become a challenging, yet pressing objective for researchers, given the growing global economic interdependence. Undoubtedly, ICT profoundly influences a nation's economic development and serves as a crucial driver of its growth.

Existing studies often rely on proxies for ICT, which may not directly capture its effects. For instance, Indijikian and Siegel (2005) assess ICT-induced changes in workforce composition, Meng and Li (2002) focus on ICT industrial development and diffusion, and Colecchia and Schreyer (2002) examine ICT capital accumulation. While some studies attempt to incorporate more direct ICT indicators, they often only consider one ICT indicator such as broadband deployment (Kolko, 2012; Thompson & Garbacz, 2011; Harindranath, 2008). Vu (2011) endeavors to address the latter gap by introducing ICT indicators such as personal computer usage and mobile phones using data from 1996 to 2005.

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To address gaps in existing literature, we introduce three ICT indicators: (a) wired high-speed internet (broadband), (b) mobile internet, and (c) satellite internet. In addition, we attempt to enhance on studies by Indijikian and Siegel (2005), Meng and Li (2002), Colecchia and Schreyer (2002), Jalavaa and Pohjolab (2002), and Holt and Jamison (2009) in several ways. Firstly, by conducting a multivariate time series analysis on the impact of ICT on all 50 US states using extensive data from 2010 to 2020. Secondly, we examine the impact of ICT at three tiers: (a) US state level, (b) manufacturing, and (c) non-manufacturing. Thirdly, we employ a more diverse set of ICT indicators – satellite internet, wired high-speed internet and mobile internet. This study empirically assesses ICT's impact on 50 US state economies, distinguishing manufacturing and non-manufacturing sectors. Key inquiries include:

(1)Does a notable correlation exist between ICT and US state economic growth, in terms of both manufacturing and non-manufacturing sectors?

(2)What ICT modes could be used to bolster state economies?

(3)What policies can amplify ICT's role in driving economic growth in sector-focused states?

The paper proceeds as follows: Section 1 discusses ICT developments of US states, spanning manufacturing and non-manufacturing domains. Section 2 presents our literature review. Section 3 presents our data and methodology. Section 4 lays out our empirical findings. Finally, Section 5 concludes.

1.1 ICT Developments in US States

US states like Ohio, Michigan, California, Kentucky, Louisiana, Tennessee, North Carolina, Indiana, among others, are manufacturing hubs, producing a wide range of globally exported goods (Schachter, 2019; US Bureau of Economic Analysis, 2010-2020). Texas leads as the top exporter, making up a substantial 17.3% of state GDP. In contrast, California is the primary importer, contributing 14.6% to state GDP (StatsAmerica, 2010-2020). States such as Texas, California, New York, Louisiana, and Illinois consistently rank in the top ten for US international trade (Buchholz, 2021).

Figure 1 displays the leading contributors to the US GDP for the manufacturing sector in 2021. Texas emerges as the foremost contributor to the US economy, accounting for 15.4% of the total state GDP, with Illinois following closely behind at 9.9%. The remaining US states contribute anywhere from just over 4% down to slightly above 0.1%.

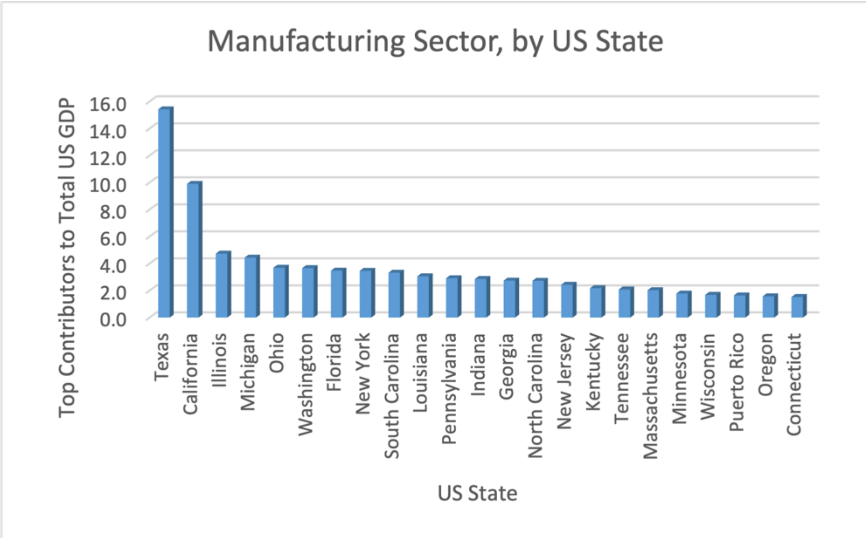

Figure 1 *2021 Top US States Contributing to Manufacturing Sector GDP*
Source: US Bureau of Economic Analysis, 2021.

Figure 2 illustrates the primary contributors to the US GDP in the non-manufacturing sector for 2021. Texas leads with a substantial 35.9% contribution, followed by California and Louisiana, both surpassing 9%. The rest of the US states contribute from 1% to 6%.

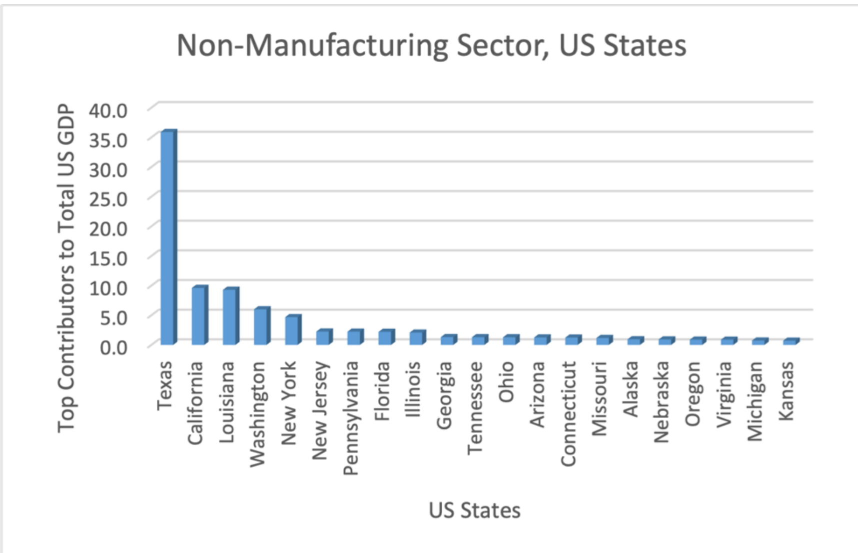

Figure 2 *2021 Top US States Contributing to Non-Manufacturing Sector GDP*
Source: US Bureau of Economic Analysis, 2021.

Figure 3 illustrates a consistent rise in Americans' internet access from 2000 to 2021. However, only 52% of the US population enjoys access to broadband internet speeds, leaving an estimated 157 million Americans without this vital service (Microsoft, 2020).

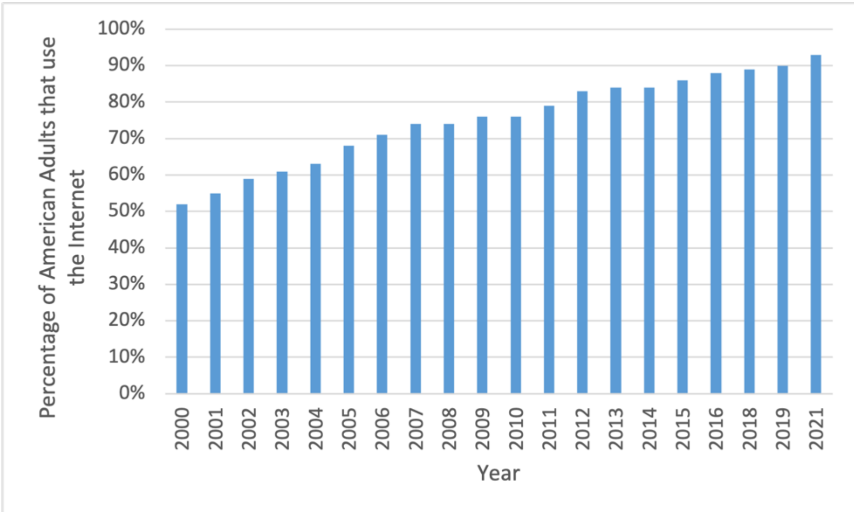

Figure 3 *Internet Usage amongst Americans (2000-2021).*
Source: Pew Research Center, 2000-2021.

Texas and California notably lead in both the manufacturing and non-manufacturing sectors, making significant contributions to the US GDP. Each state, with its distinct geography, and demographics, faces unique economic implications shaped by ICT's influence on economic growth and industry.

US states such as Arkansas, Kentucky, Mississippi and New Mexico, are still working to improve accessibility. Notable digital gaps between urban and rural communities persist. Pre-COVID, urban access was 53%, suburban was 56%, and rural was 42% (Pew Research Center, 2000-2021). Post-COVID, urban areas (95%) slightly exceeded suburban access (94%).

The aforementioned overview underscores the pivotal role individual states play in the dynamic economic landscape of the US, emphasizing the critical need for extended empirical studies on the impact of ICT on both the manufacturing and non-manufacturing sectors.

2. Literature Review

In the 1980s, early studies (Loveman, 1994; Roach, 1987; 1989; 1991; Strassmann, 1990) find limited significance of ICT on the economy. The 1990s marked a shift towards recognizing ICT's positive impact at both firm and country levels. Brynjolfsson (1993; 1995; 1996), Brynjolfsson and Hitt (1996; 1998) and Brynjolfsson, Hitt and Yang (2000) is a series of studies in the 1990s to early 2000s that emphasized the transformative role of ICT and computers in production, delineating critical distinctions among firms and driving business advancements.

In the post-1990s, literatures began to empirically assess ICT's impact on a country's economy. Wang's (1999) study in Taiwan over 16 years highlights the joint influence of national information technological capabilities and investment on economic growth. Colecchia and Schreyer (2002) conduct a comparative study across eight developed countries, including the US, from 1990 to 2000, affirming ICT's contribution to economic growth. Jalavaa and Pohjolab (2002) assess factors behind ICT's role in economic performance, observing a more pronounced impact in the US compared to other countries.

Meng and Li (2002) is a comparative study between China and developed nations that spotlights rapid progress in ICT development in both contexts. Indijikian and Siegel (2005) uses a mixed-method approach to demonstrate ICT's positive correlation with economic performance in both developed and developing nations. Harindranath (2008) examines ICT's impact on Hungary amid economic transition revealed challenges in integrating ICT into production and use. Holt and Jamison (2009) explores the positive correlation between broadband deployment and economic prosperity in the US. Vu (2011) investigates ICT's impact on economic growth, identifying internet penetration as a major driver. Thompson and Garbacz (2011) study focuses on broadband's impact on GDP, reveals a more substantial effect in low-income nations. Kolko (2012) investigates the link between broadband expansion and local economic growth, with varying impacts on industries and population densities.

Our literature review underscores ICT's undeniable significance at the country level (Wang, 1999; Colecchia & Schreyer, 2002; Jalavaa & Pohjolab, 2002; Meng & Li, 2002; Indijikian & Siegel, 2005; Harindranath, 2008; Holt & Jamison, 2009; Vu, 2011; Park & Choi, 2019). To the author's knowledge, no existing studies have yet investigated the ICT's impact at a state level (US). In this study, we use more direct ICT proxies to enhance accuracy, distinguishing from existing studies (Indijikian & Siegel, 2005; Meng & Li, 2002; Colecchia & Schreyer, 2002).

3. Data and Econometric Specifications

3.1. Data and Methodology

The dependent variable, $\text{STATE-ECONOMY}_{st,}$ is assessed using Gross Domestic Product (GDP) in current US Dollars (in millions), for each US state (s) from 2010 to 2020. GDP data is sourced from the US Department of Commerce (2010-2020). Appendix A provides a list of all 50 US states. Economic data for US states, encompassing both manufacturing and non-manufacturing sectors, is obtained from the US Bureau of Economic Analysis. Data is reported in millions of dollars and seasonally adjusted on an annual basis. (US Census Bureau, 2022; Sage Stats, 2021).

From 2010 to 2020, we assess how wired, mobile, and satellite internet impact 50 US state economies. Using advanced time series analysis, including Ordinary Least Squares regression, we bridge methodological gaps in existing research by examining manufacturing and non-manufacturing sectors.

3.2. Estimation Model for US State Economies

Our dependent variable is $\text{STATE-ECONOMY}_{st}$, where s, is a US state, at time, t, where t = 2010-2020, for all industry totals. Equation (1) estimates the impact of ICT on a US state economy:

$$\log\text{STATE-ECONOMY}_{st} = \log\text{ICT}_{st} + \gamma_s + \delta_t + e_{st} \tag{1}$$

Where, $\log\text{ICT}_{st}$, is ICT utilized in a US state, s, at time, t. Data on ICT is obtained from National Telecommunications and Information Administration (2010-2020). γ_s is a US state, s, where, s = 1...50. δ_t is our time specific effects, where, t = 2010-2020. e_{st} is our fixed or random unobserved bilateral effect for a US state, s, at time, t.

Most Americans, including those in rural areas, have access to various internet options including satellite or 5G (Jaffe, 2020). However, although satellite internet is available in remote regions, it offers slower speeds compared to landline connections (Schafer, 2019). In rural parts of the US where wired providers such as DSL, cable, or fiber aren't available, satellite internet presents a viable alternative (BroadbandNow, 2021). Despite narrowing digital gaps post-COVID-19, disparities persist. Rural Americans are less likely to have broadband access or own smart devices (Perrin, 2019; Vogels, 2021). Disparities span regions, states, cities, ethnicities, education levels and incomes. We address these digital disparities through three modes of ICT: (a) wired high-speed internet, (b) mobile internet, and (c) satellite internet, and aim to cover rural, suburban and urban areas, while accounting for community behavior and user preferences.

Equation (3) estimates the impact of ICT of wired high-speed internet ($\log\text{WIRED}_{st}$), mobile internet ($\log\text{MOB}_{st}$) and satellite internet ($\log\text{SAT}_{st}$) on the economy of a US state:

$$\log\text{STATE-ECONOMY}_{st} = \log\text{WIRED}_{st} + \log\text{MOB}_{st} + \log\text{SAT}_{st} + \gamma_s + \delta_t + e_{st} \tag{3}$$

Where, $\log\text{STATE-ECONOMY}_{st}$ is the economy of a US state, s, at time, t. γ_s is the fixed effects of a US state, s, at where, s = 1...50; at time, t. δ_t is the time specific effects, where, t = 2010-2020. e_{st} is our fixed or random unobserved bilateral effect for state, s, at time, t.

3.3. Estimation Model for US States – Manufacturing Sector

Equation (4) is used to estimate the impact of ICT on a US state economy in terms of manufactured industry:

$$\log\text{STATE-ECON-MFD}_{st} = \log\text{WIRED}_{st} + \log\text{MOB}_{st} + \log\text{SAT}_{st} + \gamma_s + \delta_t + e_{st} \tag{4}$$

Where, $\log\text{STATE-ECON-MFD}_{st}$ is a US state economy in terms of manufactured industry for a US state, s, at time, t. γ_s is the fixed effects of a US state, s, at where, s = 1...50; at time, t. δ_t is the time specific effects, where, t = 2010-2020. e_{st} is our fixed or random unobserved bilateral effect for state, s, at time, t.

3.4. Estimation Model for US States – Non-manufacturing Sector

Equation (5) is used to estimate the impact of ICT on each US state economy in terms of manufactured goods:

$$\log\text{STATE-ECON-NON-MFD}_{st} = \log\text{WIRED}_{st} + \log\text{MOB}_{st} + \log\text{SAT}_{st} + \gamma_s + \delta_t + e_{st} \tag{5}$$

Where, $\log\text{STATE-ECON-NON-MFD}_{st}$ is the log of a US state economy, in terms of non-manufactured goods for a US state, s, at time, t. γ_s is the fixed effects of a US state, s, at where, s = 1...50; at time, t. δ_t is the time specific effects, where, t = 2010-2020. e_{st} is our fixed or random unobserved bilateral effect for state, s, at time, t.

4. Empirical Results

4.1. Descriptive Statistics

Tables 1, 2, and 3 present the Pearson correlation coefficients for (a) US state economies, (b) US state economies concerning manufactured goods, and (c) US state economies regarding non-manufactured goods, respectively. Table 1 displays Pearson correlation coefficients illustrating the impact of ICT on a US state's economy. The data reveals a robust relationship between wired internet accessibility and a state's economic performance, with a coefficient of 0.983. Following closely is mobile internet, showing a strong correlation of 0.925, while satellite internet exhibits a slightly lower correlation at 0.792. This ranking underscores the dominant influence of wired internet, followed by mobile internet, and satellite internet in shaping a state's economy. It also suggests untapped potential for further leveraging mobile and satellite internet to bolster overall economic growth in US states.

Table 1 *Correlation Coefficients for the Impact of ICT on the Overall US Economy*

	Overall US State Economy	$WIRED_{st}$	MOB_{st}	SAT_{st}
Overall State $Economy_{st}$	1.000			
$WIRED_{st}$	0.983	1.000		
MOB_{st}	0.825	0.797	1.000	
SAT_{st}	0.792	0.805	0.780	1.000

Notes:
a. Overall State $Economy_{st}$ is impact of ICT on the overall economy of a US state, s, at time, t.
b. $WIRED_{st}$ is the wired high-speed internet service in state, s, at time, t.
c. MOB_{st} is the mobile internet service in state, s, at time, t.
d. SAT_{st} is the satellite internet service in state, s, at time, t.

Table 2 displays Pearson correlation coefficients for ICT's impact on US state economies in manufactured goods. Wired internet exhibits the strongest relationship at 0.985, followed by satellite internet at 0.829, and mobile internet at 0.769. This ranking mirrors the overall state economy's ICT drivers, highlighting wired internet's significance. The study's findings indicate similar patterns for a state's economy and the overall economy.

Table 2 *Correlation Coefficients for the Impact of ICT on US State Economies for Manufactured Goods*

	State Economy For Manufactured Goods	$WIRED_{st}$	MOB_{st}	SAT_{st}
State Economy For Manufactured $Goods_{st}$	1.000			
$WIRED_{st}$	0.985	1.000		
MOB_{st}	0.769	0.796	1.000	
SAT_{st}	0.829	0.806	0.779	1.000

Notes:
a. State Economy for Manufactured $Goods_{st}$ is impact of ICT on the overall economy of a US state, s, in terms of manufactured goods, at time, t.
b. $WIRED_{st}$ is the wired high-speed internet service in state, s, at time, t.
c. MOB_{st} is the mobile internet service in state, s, at time, t.
d. SAT_{st} is the satellite internet service in state, s, at time, t.

Comparing Pearson correlation coefficients in Tables 1 and 2, we observe that wired internet exhibits a robust impact on both state economy and the economy in manufactured goods, exceeding 98%. Mobile internet has a stronger influence on the overall state economy compared to the economy in manufactured goods. Approximately 23.1% growth potential exists for mobile internet in the manufacturing sector of each state. Increasing mobile internet accessibility and satellite subscriptions are both essential for states aiming to boost their economies in manufactured goods.

Table 3 displays Pearson correlation coefficients indicating the impact of ICT on state economies in non-manufactured goods. Results reveal the strongest relationship with wired internet accessibility at 0.714, followed by satellite internet at 0.520, and mobile internet at 0.401. Results from Table 3 show that the ranking of the drivers of ICT is strongest for wired internet, followed by mobile internet, and finally satellite internet.

Table 3 *Correlation Coefficients for the Impact of ICT of US State Economies for Non-Manufactured Goods.*

	State Economy For Non-manufactured Goods	$WIRED_{st}$	MOB_{st}	SAT_{st}
State Economy For Non-manufactured $Goods_{st}$	1.000			
$WIRED_{st}$	0.714	1.000		
MOB_{st}	0.401	0.797	1.000	
SAT_{st}	0.520	0.805	0.780	1.000

Notes:
a. State Economy For Non-manufactured $Goods_{st}$ is impact of ICT on the overall economy of a US state, s, in terms of non-manufactured goods, at time, t.
b. $WIRED_{st}$ is the wired high-speed internet service in state, s, at time, t.
c. MOB_{st} is the mobile internet service in state, s, at time, t.
d. SAT_{st} is the satellite internet service in state, s, at time, t.

The results across Tables 1, 2, and 3 consistently demonstrate strong positive correlations between wired internet and state economies, both for manufactured and non-manufactured goods. This robust consistency underscores the pivotal role of wired internet infrastructure in driving economic activity across sectors. Additionally, the correlations consistently above 0.7 highlight the significant relationship between wired internet accessibility and economic performance, emphasizing its importance as a driver of economic growth.

When we compare the correlations between different ICT services (wired, mobile, satellite) within each Table (1, 2 and 3), we are able to demonstrate their relative importance in influencing economic outcomes. For example, in Table 2, wired internet exhibits the highest correlation with the state economy for manufactured goods, indicating its greater significance compared to mobile and satellite internet services in this particular sector.

Results shown in Tables 1, 2 and 3, find that the impact of ICT services on economic performance is sector-specific. For instance, while wired internet consistently shows strong correlations across all sectors, the correlations for mobile and satellite internet services vary, with mobile internet exhibiting stronger correlations with the overall state economy compared to the economy for manufactured goods in Table 2. Therefore, we suggest the importance of prioritizing investments in wired internet infrastructure to stimulate economic growth across various sectors.

4.2. Comparative Descriptive Statistics

Results from Table 4 show that US states that thrive heavily on manufactured goods as an economic driver utilize all three forms of ICT (wired internet, mobile internet and satellite internet) more strongly than state economies that thrive on non-manufactured goods. US states that intend to drive more of their economies on non-manufactured goods could increase and promote utilization of mobile internet, followed by satellite internet, and finally, wired internet.

The correlation coefficients in Tables 1, 2 and 3 highlight the influence of ICT on various aspects of state economies. Wired internet exhibits the strongest impact on manufactured goods, followed by the overall state economy and non-manufactured goods. This suggests a significant reliance on wired internet for the manufacturing sector. Mobile internet's impact is strongest on the overall state economy, followed by manufactured goods and non-manufactured goods.

Table 4 *Comparison of Correlation Coefficients for the Impact of ICT of US State Economies.*

	State Economy$_{st}$		State Economy for Manufactured Goods$_{st}$		State Economy for Non-manufactured Goods$_{st}$
WIRED$_{st}$	0.983	$<$	0.985	$>$	0.714
MOB$_{st}$	0.825	$>$	0.769	$>$	0.401
SAT$_{st}$	0.792	$<$	0.829	$>$	0.520

Notes:
a. Overall State Economyst is impact of ICT on the overall economy of a US state, s, at time, t.
b. State Economy for Manufactured Goodsst is impact of ICT on the overall economy of a US state, s, in terms of manufactured goods, at time, t.
c. State Economy for Non-manufactured Goodsst is impact of ICT on the overall economy of a US state, s, in terms of non-manufactured goods, at time, t.
d. WIREDst is the wired high-speed internet service in state, s, at time, t.
e. MOBst is the mobile internet service in state, s, at time, t.
f. SATst is the satellite internet service in state, s, at time, t.

In Table 5, models (a), (b), and (c), we employ Ordinary Least Squares to estimate the impact of ICT on state economies, focusing on overall, manufactured, and non-manufactured goods. Notably, the models perform exceptionally well for manufactured goods, surpassing their performance for non-manufactured goods by over 23%.

Table 5 outlines Model (a) findings, emphasizing wired, mobile, and satellite internet's significant 0.01% impact on the entire US state economy. Wired internet leads with a coefficient of 0.926, followed by mobile at 0.134. Satellite internet, with -0.053, indicates an inverse correlation with wired and mobile usage, highlighting its relevance in remote areas.

In Model (b), Table 5 illustrates notable insights. Wired and satellite internet exhibit significant 0.01% impacts on the overall state economy for manufactured goods, while mobile internet lacks significance. This suggests a preference for traditional ICT in manufacturing applications. Wired and satellite internet demonstrate comparable impacts in Model (b), with coefficient values of 0.051 and 0.049 respectively.

Model (c) in Table 5 shows both wired and mobile internet with 0.01% significance for the non-manufacturing sector. This contrasts their impact on the manufacturing sector, where mobile internet stands as highly significant. In terms of coefficient values, wired internet carries a 0.054 value, indicating greater influence on the non-manufacturing sector compared to mobile internet, which shows 0.041.

4.3. Full Sample Analysis

Table 5 *Estimates for the Impact of ICT on US State Economies, 2010-2020.*

Models	(a)	(b)	(c)
Dependent Variables	*State Economy*	*State Economy – Manufactured Goods*	*State Economy – Non-manufactured Goods*
$log\mathrm{WIRED}_{st}$	0.926 (45.299)****	0.051 (19.255) ****	0.054 (13.765)****
$log\mathrm{MOB}_{st}$	0.134 (6.968)****	0.038 (-0.414)	0.041 (13.765)****
$log\mathrm{SAT}_{st}$	-0.053 (-2.681)***	0.049 (5.706)****	0.053 (0.403)
Constant	1.314 (-8.772)****	0.372 (32.263)****	0.399 (-9.983)****
Adjusted R^2	0.998	0.944	0.767
No. of states	50	50	50
No. of observations	500	498	500
Durbin Watson	2.335	1.814	1.324
F-test	2827.340	665.583	117.062
VIF values	3.589 3.222 3.348	(a) 3.585 (b) 3.205 (c) 3.346	3.589 3.222 (c) 3.348

Notes: The independent variables are as follows: (a) $\log\mathrm{WIRED}_{st}$ is the wired high-speed internet service in a state, s, at time, t; (b) $\log\mathrm{MOB}_{st}$ is the mobile internet service in state, s, at time, t; (c) $\log\mathrm{SAT}_{st}$ is the satellite internet service in state, s, at time, t. The explanatory variables are as follows: (a) State $\mathrm{Economy}_{st}$ is impact of internet and its related ICT on US state economies, in state, s, at time, t; (b) State Economy – Manufactured Goods_{st} is impact of internet and its related ICT on US state economies, in terms of manufactured goods, in state, s, at time, t. (c) State Economy – Non-manufactured Goodsst is the impact of ICT on US state economies, in terms of non-manufactured goods, in state, s, at time, t. t-statistics are in parentheses, *significant at 10%.

Across all models (a), (b), and (c) in Table 5, a consistent finding is the profound significance of wired internet across three tiers of US state economies: overall state economies, state economies in terms of manufactured goods, and state economies in terms of non-manufactured goods. This underlines wired internet's enduring reliability as a catalyst for economic growth and sustainability in US states. Thus, the results from the regression models shown in Table 5 provide valuable insights both in terms of overall economic performance and sector-specific outcomes as summarized below:

(a) Significance of Wired Internet ($\log\mathrm{WIRED}^{st}$):

The coefficient for $\log\mathrm{WIRED}^{st}$ is consistently positive and statistically significant across all three models (a), (b), and (c). This suggests that an increase in wired high-speed internet service in a state is associated with a significant positive impact on the state's economy, whether considering overall economic performance or sector-specific outcomes. The high adjusted R-squared values 0.998 in model (a) indicate that the model explains a large proportion of the variation in state economies, with wired internet making a substantial contribution.

(b) Mixed Results for Mobile Internet ($\log\mathrm{MOB}^{st}$):

The coefficients for $\log\mathrm{MOB}^{st}$ is positive and statistically significant in models (a) and (c), but not (b). This suggests that while mobile internet service may have a positive impact on the overall state economy, its influence on sector-specific outcomes, particularly in the non-manufactured goods sector, is less clear. The lower adjusted R-squared values in models (b) and (c) indicate that mobile internet may have a relatively smaller explanatory power compared to wired internet.

(c) Mixed Impact of Satellite Internet ($\log\mathrm{SAT}^{st}$):

The coefficient for $\log\mathrm{SAT}^{st}$ varies across models, but generally shows mixed results in terms of statistical significance. In model (b), $\log\mathrm{SAT}^{st}$ is statistically significant and positively associated with the state economy for manufactured goods, suggesting a potential impact. However, in model (c) the coefficient for $\mathrm{longSAT}^{st}$ is not statistically significant for non-manufactured goods. Overall, the results suggest that satellite internet service may have a limited impact on state economies compared to wired and mobile internet services.

4.4. Non-Crisis Period Analysis

The implications of the above results suggest several key points for policymakers and businesses in the following areas:

(a) **Significance of Wired Internet:**

The consistently high Pearson correlation coefficients for wired internet across Tables 1, 2 and 3 indicate its paramount importance in driving economic activity, both in manufactured and non-manufactured goods sectors. This underscores the need for continued investment in wired internet infrastructure to support economic development initiatives.

(b) Opportunities for Mobile Internet Growth:

While mobile internet exhibits a strong impact on the overall state economy, its potential in the manufacturing sector remains largely untapped. The substantial growth potential of approximately 23.1% suggests that focusing on increasing mobile internet accessibility could significantly boost manufacturing economies in states.

(c) Importance of Satellite Internet:

Although satellite internet exhibits lower correlation coefficients compared to wired and mobile internet, its impact on both manufactured and non-manufactured goods sectors is notable.

4.5. Crisis Period Analysis – COVID-19

In the manufacturing sector, COVID-19 disrupted global supply chains, leading to supply shortages, production delays, and increased demand for digitalization. States with robust ICT infrastructure were better positioned to adapt to remote work, implement smart manufacturing technologies, and maintain productivity amidst the disruptions. However, disparities in ICT access and digital skills may have widened the gap between technologically advanced and less-developed regions, impacting economic resilience and recovery.

Similarly, in non-manufacturing sectors such as services, COVID-19 accelerated digital transformation initiatives. Businesses pivoted to online sales channels to adapt to changing consumer behavior and public health restrictions. States with higher ICT penetration rates experienced smoother transitions and were better able to leverage digital technologies to mitigate the economic impact of the pandemic. In conclusion, COVID-19 underscores the importance of ICT infrastructure and digital readiness in supporting economic resilience.

5. Conclusion

This study delves into the pivotal role of ICT in shaping the economic landscapes of US states. The findings highlight significant contributions from wired internet, mobile internet, and satellite internet to state economies. Notably, wired internet emerges as a vital factor across all 3 tiers. Findings highlight the need for tailored ICT strategies based on a state's industrial focus and geographic characteristics. This study acknowledges the importance of factors such as remoteness, accessibility costs and socio-economic disparities in crafting broadband packages.

There are several practical implications for the US and other countries looking to leverage ICT for economic development in terms of ICT infrastructure investment or policy formulation. Countries should prioritize investment in ICT infrastructure, particularly wired and mobile internet networks. For example, countries like South Korea and Singapore have made significant investments in broadband infrastructure driving economic productivity.

Collaboration between government, industry, and academia is essential for maximizing the economic benefits of ICT. Countries should encourage partnerships that facilitate technology transfer and skill development. For instance, initiatives like Germany's Industry 4.0 strategy promote collaboration between manufacturers, technology providers, and research institutions to drive innovation in manufacturing processes.

While this study provides valuable insights, it acknowledges certain limitations. Future research should explore the impact of ICT on states' economic growth considering factors like geographical sparsity and costs. Additionally, a comparative analysis of pre- and post-COVID periods could offer further insights into ICT's influence on both manufacturing and non-manufacturing sectors. This research aligns with earlier studies, affirming the positive correlation between ICT and economic performance (Colecchia & Schreyer, 2002; Indijikian & Siegel, 2005; Holt & Jamison, 2009). In summary, ICT plays a pivotal role in shaping state and national economies, whether in the manufacturing or non-manufacturing sectors. It is imperative to prioritize ongoing efforts aligned with ICT advancements to narrow the digital divide and ensure widespread access to updated technologies.

Appendix A. List of 50 US States

Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

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