How Taiwan's Broadband Program Can Continue to Improve Internet Usage: Evidence from Panel Data

Shui-Lien Chen[1,2], Chih-Jen Chen[1], Yung-Hsin Lee[3], Angelina Nhat Hanh Le[4]*

[1] Department of Management Sciences, Tamkang University, Taiwan
[2] Adjunct Research Fellowship of University of Economics Ho Chi Minh City, Vietnam
[3] Department of International Business, Tamkang University, Taiwan
[4] Research Methodology Department, University of Economics Ho Chi Minh City, Vietnam
135938@o365.tku.edu.tw, 810620038@gms.tku.edu.tw, 138332@o365.tku.edu.tw, hanhln@uch.edu.vn

Abstract

Since 2002, Taiwan has given a significant amount of public subsidies to projects aimed at improving its information and communication infrastructure and these programs have a budget greater than 250 billion NTD. The goal of addressing the first-order digital divide is still in progress, whether the second-order digital divide exists has a groups effect is unclear? Is there any difference in the periods effect? The impact between groups and periods of panel data between 2011 and 2022 was evaluated using the least squares dummy variables model in this study. According to the empirical analysis, ten administrative districts, including Taipei City, are experiencing challenges in bridging the digital divide even though the digital gap and internet usage rates are not identical. Cable and mobile operators are crucial for boosting internet usage and closing the digital divide. The digital divide will worsen due to the economic gap caused by mobile device (e.g. smartphones, tablets) ownership compared to household characteristics. While the government continues to invest in broadband construction and improve internet access to reduce the first-order digital divide, regional differences in internet usage should be further explored, to clarify and address the problem of the second-order digital divide according to local conditions.

Keywords: Digital divide, Rural development, Internet usage, Least squares dummy variables, Taiwan

1 Introduction

In 1995, the existence of various digital divides in internet access was initially documented by the Clinton administration in a series of reports entitled "Falling through the Net" by the National Telecommunications and Information Administration (NTIA) in the U.S. [1]. In 2001, the OECD declared that the digital divide refers to "the gap between individuals, households, businesses, and geographic areas at different socioeconomic levels with regard both to their opportunities to access information communication technologies (ICTs) and to their use of the internet for a wide variety of activities" [2]. A deep understanding of the digital divide is particularly important for policymakers to design effective measures, because bridging the digital divide has often been considered a solution for economic growth and development, as well as for inequality and poverty reduction [3].

In 2005, [4] examined both first and second order effects of the digital divide at three levels of analysis, the individual level, the organizational level, and the global level. First-order effects regarding inequality in access to ICT, and second-order effects regarding inequality in the ability to use ICT among those who already have access to ICT. In 2023, [5] presented a literature review over the last decade (2010-2020) of information systems research on the digital divide in settings with advanced technological infrastructures and economies. The digital divide is commonly described as a digital divide cascade that is characterized by various forms of inequality, such as unequal capabilities, engagement, use outcomes, and access. In advanced economies with robust digital infrastructures, and physical access is a less significant factor in digital inequality, which concerns differences in digital skills, autonomy, social support and the aims of digital technology use. Beyond socioeconomic demographics, the literature has identified personal factors such as motivation, personality traits, and digital skills.

Since 2002, Taiwan has actively made efforts to narrow the digital divide using public funds, including by providing subsidies for fiber-optic construction and policies to expand wireless broadband internet access. In recent years, an average of 20 billion new Taiwan dollars (NTDs) have been invested annually in the construction of high-speed broadband networks. According to the Survey of Digital Opportunities in Individual Households conducted by the National Development Council (NDC), as shown in Figure 1, the average proportion of households with internet usage increased from 61.1% to 87.2% from 2004 to 2023. The dataset did not include data for 2021 due to the incompleteness of government statistics. Following these investments, there was an overall growth trend in internet usage. Since 2018, the central government has budgeted for the formulation of a nationally consistent subsidy method

*Corresponding Author: Chih-Jen Chen; Email: 810620038@gms.tku.edu.tw
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for expanding broadband into rural areas and adopted the construction methods proposed by telecom providers and local governments.

While the government continues to invest in broadband construction and improve internet access to reduce the first-order digital divide, regional differences in internet usage should be explored to understand and address the problem of the second-order digital divide according to local conditions.

2 Literature Review and Hypothesis Development

2.1 Evaluation of the Impact of Public Subsidy Schemes

Recently, scholars have applied various models to assess the benefits or impacts of public subsidies invested in rural broadband-related construction.

In Kenya, [6] used survey data focused on narrowing the digital divide by setting up a community technology center (CTC) in the Mathare Slum to offer free community internet access and training in digital literacy skills. According to [7] used a qualitative methodology, to show that wireless technologies could be more efficient. However, it suggested that Ghana's universal internet access goals may not be achievable due to its inefficient and outdated fixed-line technologies and infrastructure. [8] presented an approach to support decision evaluation using open-source software. Targets considered by the United Nations' Broadband Commission were evaluated, with the financial costs of different infrastructure decisions quantified for the whole African continent. [9] using the nonlinear decomposition method, stated that a large first level and second level digital divide between disadvantaged caste groups and others exists in India. The findings of this study highlighted the urgent need to address educational and income inequality among the different caste groups in India to bridge the digital divide.

[10] used data regarding the allocation of 2014–2020 EU funds, to analyze the relationship between local needs and investment decisions to bridge geographic digital divides. Regional strategies, each with the policy goals of broadband access, digital inclusion, digital government services, and the use of ICTs in enterprises were identified. [11] used Eurostat panel data from 2014–2020 and found that in highly developed EU countries, such as Estonia, the Netherlands, Denmark, and Norway, the relationship between internet usage and digital performance is strong.

Ref. [12] used residential and business surveys, and a Canadian Internet Registration Authority (CIRA) internet performance test (IPT) to explore the challenges of evidence-based decision-making in the design and implementation of rural broadband investment programs. [13] analyzed the role of regulation in achieving the broadband penetration goals defined by the National Regulatory Authority in Finland. Based on ten patterns the researchers argued that the Finnish spectrum policy encouraged mobile network operators to satisfy ambitious universal service obligations without the need for a universal service fund.

According to the above literature in which many methods were used to measure public subsidies for broadband programs, the internet usage associated with the second-order digital divide was used to assess digital performance and to measure the impact of broadband programs on different countries or regions.

2.2 The Effects of the Broadband Program

In addition to examining the policy direction of investing in broadband programs, many scholars have discussed the benefits of investing in these programs in various countries. Research has shown that there are differences in the direction of development between developing and developed countries that contribute to addressing the digital divide.

According to research in the USA, in many developed countries, the effect of improved broadband quality in rural areas appears to be disproportionately greater than that in non-developed countries [14]. A Finnish study [15] revealed that the availability of broadband decreases depopulation in remote and sparsely populated rural areas. A study focusing on high-speed broadband in the U.S. state of Tennessee [14] examined the effects of broadband speed on county unemployment rates. Additionally, a German study of the unemployment rate [16] noted that a growing body of literature has noted the positive impacts of start-up subsidies (SUS) on the labor market outcomes of participants. From a different perspective, [17] considered internet use for work among teleworkers in Canada, estimated the telecommuter surplus in southwestern Ontario, and found that employment costs, including opportunity costs, decreased as this surplus increased.

In contrast to studies in developed countries, a Latin American study [18] noted that despite the significant progress in the digitization of consumption, the region still faces important development challenges related to its digital economy. Another study [19] in Romania reported low levels of customer satisfaction and revealed that users are more inclined toward data transfer than voice or video applications. Ref. [20] investigated the relationship between internet access and economic growth in sub-Saharan Africa (SSA), and the findings revealed a significant growth effect above an internet threshold of 3.55%. In China, information and communication technology (ICT), represented by the broadband internet, has had a profound impact on the urban labor market. Ref. [21] found that access to broadband internet is positively related to the intercity income gap.

According to the literature, broadband programs in developed countries have the potential to reduce the population decline in rural areas and the unemployment rate but there is little mention of substantial improvements in internet usage on this topic. Instead, in developing countries, network infrastructure can foster an environment that is conducive to the efficient use of related products, it is easy to categorize the measures that improve the digital divide in broadband programs as necessary for construction.

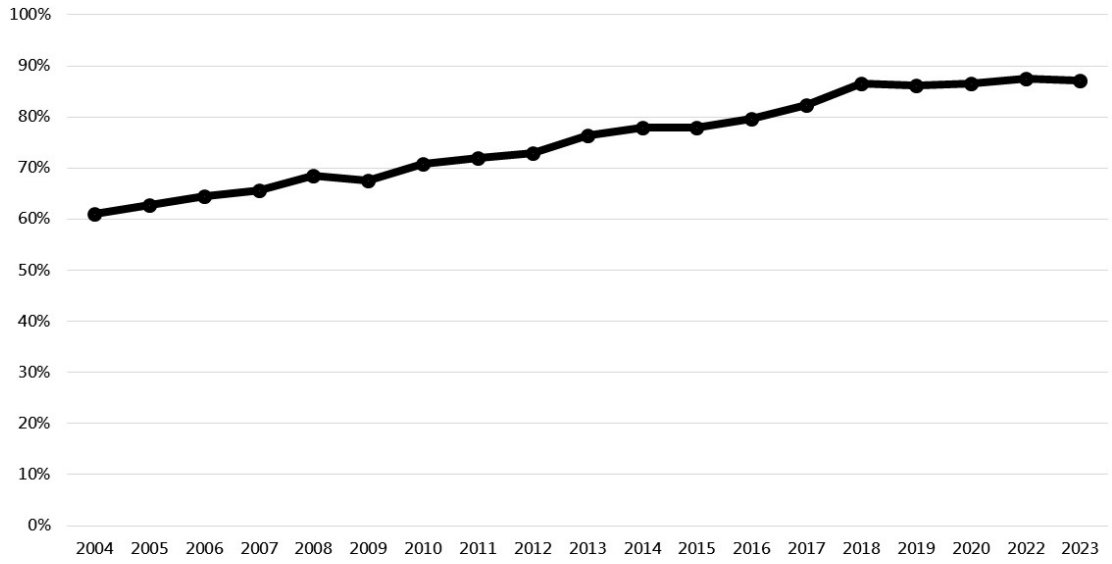

Figure 1. Internet usage from 2004 to 2023

Source: The Survey of Digital Opportunities in Individual Households conducted by the NDC

2.3 The Broadband Program in Taiwan

Since 2002, Taiwan has invested substantial national funds in projects that aim to develop its information and communication infrastructure. The cumulative budget allocated for these programs has exceeded 250 billion NTD. The first was the e-Taiwan program (2003-2007), which was launched with the objective of promoting the development and adoption of information and communication technologies (ICTs) in Taiwan. The goals of this program were to drive economic growth, enhance public services, and improve the quality of life for Taiwanese citizens by promoting the use of ICTs. One of the aims of the program was to connect 6 million households with home broadband at a speed of at least 2 M bps.

The second was the M-Taiwan program (2005-2009), which aimed to promote the development of Taiwan's mobile communication industry and support the creation of new mobile applications and services. The goal of this program was to increase Taiwan's competitiveness in the global mobile industry, create new business opportunities, and promote the use of mobile technology in various aspects of daily life. In addition, the program aimed to enhance the user experience of mobile devices and services and improve the overall quality of life for Taiwan's citizens. One of the expectations of the program was to support eight million wireless internet users.

The third program was the i-Taiwan program (2010-2016), which aimed to build a world-class information and communication infrastructure in Taiwan with the goal of enhancing the country's international competitiveness and improving the quality of life for its citizens. The program aimed to create a more connected and technologically advanced society and to foster economic growth, social development, and global competitiveness in Taiwan. One of the expectations of the program was to achieve internet access at a data transfer speed of 100 Mbps for 80% of the population by 2015.

The current program is the Digital Nation and Innovative Economic Development Program (Digi+) (2017-2025), which aims to promote the development of Taiwan's digital economy and support innovation, entrepreneurship, and investment in key emerging technology sectors. The program seeks to position Taiwan as a global leader in the digital economy, with a particular focus on emerging technology sectors. By promoting innovation, entrepreneurship, and investment in these areas, the program aims to drive economic growth, create new job opportunities, and improve the quality of life for Taiwan's citizens. Two expectations of the program were to achieve high-speed broadband service of up to 1 Gbps with 90% coverage by 2020 and high-speed broadband service of up to 2 Gbps with up to 90% coverage by 2025. The program supported the construction of broadband in rural townships and villages in Taiwan. The goal of addressing the first-order digital divide is still in progress. According to the 2018-2022 analysis of the areas that received a subsidy to expand rural broadband access, Taipei City and three local cities did not receive any subsidies. Approximately 15%, 15.6%, and 69.4% of the total available funds are allocated to municipalities, outlying islands, and other counties, respectively. The subsidy is allocated to cable operators at 17%, followed by mobile phone operators at 30%, and others who support incumbent fixed-line operators.

The literature discussion above has resulted in the following points:

1. The second-order digital divide's internet usage was used to measure digital performance, which is appropriate.

2. Broadband programs in developed countries have made little mention of substantial improvements in internet usage.

3. In Taiwan, a broadband program that has been ongoing for more than 20 years, the goal of addressing the first-order digital divide is still in progress, and whether a second-order digital divide exists in the groups effect is unclear. Any differences in the effects during the period are also worth defining.

The goal of this study is to test whether government investment can mitigate the digital divide and effectively improve internet usage to reduce digital disparities.

1. Is there a second-order digital divide (e.g. internet usage) in development among municipalities, counties, cities, and outlying islands?

2. Will the increase in broadband internet service providers, such as mobile telecommunications and cable TV providers, have an impact on the digital divide?

3 Methodology

3.1 Data Description

Taiwan has a total of 22 local self-governing administrative units divided into municipality, county, outlying island and city levels (Table 1). This analysis uses matched data from five nationally representative datasets: the Individual/Household Digital Opportunity Survey Report, National Statistics, Low Income Survey, Labor Statistics and National Demographic Data. The Individual/Household Digital Opportunity Survey Report covers internet usage and the computer ownership rate, and the data are obtained from the NDC database and based on demographic surveys of counties and cities.

The national statistics include the proportion of the elderly population, household consumption expenditures, the proportion of cable TV subscribers, and the mobile phone ownership rate. The data were collected from the Directorate General of Budget, Accounting and Statistics (DGBAS).

Households and persons in low-income families were used to determine the proportion of low-income heads of household, and the data were collected from every local self-governing administrative unit. The labor statistics collected by the Ministry of Labor provided the household savings rate. Data from a national demographic survey were used to calculate the ratio of the population with a college education or higher, and this survey was administered by the Ministry of the Interior.

We constructed the panel data dataset for analysis by matching the five primary data sources mentioned earlier with city- or county-specific codes. The data of 22 self-governing administrative units were collected from 2011 to 2022. The government statistical units conduct annual sample surveys that yield three variables, namely, internet usage, computer ownership rate at the household level, and household consumption expenditures. The remaining six variables are based on demographic data. The dataset did not include data from 2013 and 2021 due to the completeness of government statistics.

Table 1. Basic information for Taiwan's autonomous administrative districts

	Government type	Land area (km^2)	Population (2020)	Density
Taipei City	Municipality	271.8	2,602,418	9,574.8
New Taipei City	Municipality	2,052.57	4,030,954	1,963.9
Taoyuan City	Municipality	1,220.95	2,268,807	1,858.2
Taichung City	Municipality	2,214.90	2,820,787	1,273.6
Tainan City	Municipality	2,191.65	1,874,917	855.5
Kaohsiung City	Municipality	2,951,85	2,765,932	937.0
Yilan County	County	2,143.63	453,087	211.4
Hsinchu County	County	1,427.54	570,775	399.8
Miaoli County	County	1,820.31	542,590	298.1
Changhua County	County	1,074.40	1,266,670	1,179.0
Nantou County	County	4,106.44	490,832	119.5
Yunlin County	County	1,290.83	676,873	524.4
Chiayi County	County	1,903.64	499,832	262.4
Pingtung County	County	2,775.60	812,658	292.8
Taitung County	County	3,515.25	215,261	61.2
Hualien County	County	4,628.57	324,372	70.1
Keelung City	City	132.76	367,577	2,768.8
Hsinchu City	City	104.15	451,412	4,334.1
Chiayi City	City	60.03	266,005	4,431.5
Penghu County	Outlying islands	126.86	105,952	835.2
Kinmen County	Outlying islands	151.66	140,597	927.1
Lienchiang County	Outlying islands	28.80	13,279	461.1

3.2 Measurement

1) Dependent variable

This study used internet usage as a dependent variable based on the Individual/Household Digital Opportunity Survey, which was conducted in 22 self-governing administrative units from 2011 to 2022. Internet usage was defined as the experience of using a computer or other information device, such as a smartphone, television, or tablet, to access the internet, regardless of whether it was connected through a fixed network, Wi-Fi, 4G, 5G, or any other type of connection.

2) Independent variables

Considering previous empirical studies on internet usage attributes ([2, 14, 22-25]), we sorted the attributes associated with households and individuals as independent variables. The household components included the proportion of low-income households, household consumption expenditures, the household savings rate, the ratio of cable TV subscribers, the mobile phone ownership rate and the computer ownership rate among households. The individual data included the proportion of the population older than 65 years old and the proportion of the population with a college education or higher. All the data were based on public government information from 22 self-governing administrative units from 2011 to 2022.

The ratio of low-income households was defined as the proportion of low-income households to the total number of households.

Household consumption expenditure was defined as the average total consumption expenditure per household.

The household savings rate was defined as the average amount of money saved by each household as a percentage of its total income.

The proportion of cable TV subscribers was defined as the number of cable TVs per household.

The ownership rate of mobile phones was defined as the number of mobile phones per person.

The ownership rate of computers among households was defined as the number of home computers per household.

The ratio of the elderly population was defined as the proportion of the population aged 65 years and older to the total population.

The college-educated population ratio was defined as the number of college graduates as a percentage of the total population.

Table 2 presents the descriptive statistics of the demographic characteristics for each variable.

Table 2. Descriptive statistics of demographic characteristics

Variable	N*T	Mean	Std. Dev.	Min	Max
Internet usage	220	0.794	0.074	0.595	0.933
Low-income family ratio	220	1.4588	0.908	0.29	6.11
Household consumption expenditures	220	706,498	154,471	433,133	1,152,501
Household savings rate	220	0.243	0.064	0.126	0.439
Proportion of the elderly population	220	0.143	0.028	0.084	0.217
Proportion of college-educated individuals	220	0.409	0.083	0.240	0.642
Cable TV subscriber ratio	220	0.831	0.099	0.567	1.048
Mobile phone ownership rate	220	2.234	0.263	1.649	2.735
Computer ownership rate at the household levels	220	0.887	0.284	0.417	1.895

3.3 Empirical Design

In this study, an LSDV model is constructed with internet usage as the dependent variable and the ratio of low-income households, household consumption expenditures, the household savings rate, the ratio of elderly people to the total population, the proportion of the population that is college educated, the cable TV subscriber ratio, the rate of mobile phone use and the computer ownership rate are the independent variables. Twenty-one dummy variables were introduced into the regression to account for city/county heterogeneity, treating Taipei City as the benchmark:

$$Internet\_usage_{it} = \sum_{j=1}^{22} \alpha_j D_{ji} + \beta_1 Percent\_lowincome_{it} + \beta_2\, Consumption_{it} + \beta_3\, Saving\_rate_{it} + \beta_4\, Ratio\_elder_{it} + \beta_5\, Ratio\_above\_college_{it} + \beta_6\, Ratio\_CableTV_{it} + \beta_7\, Mobile\_rate_{it} + \beta_8\, Computer_{it} + \mu_{it}$$

where

$D_{jt} = 1$ when j = i

$D_{jt} = 0$ when j ≠ i

α_1 represents the intercept of Taipei city, and $\alpha_2, \alpha_3, ..., and\ \alpha_{22}$ are the differential intercept coefficients, which indicate how much the intercepts of New Taipei City, Taoyuan City, ..., and Lienchiang County differ from the intercept of Taipei city.

$H_0 : \alpha_1 = \alpha_2 = \alpha_3 ... = \alpha_{22}$

$H_1 :$ *not all* α_i *are equal for* $i = 1, 2, ..., 22$

β_1 is the slope of the dependent variable, reflecting the ratio of low-income households to total households. It represents the expected annual percentage change in internet usage growth per percentage change in the proportion of low-income households given that other regressors are constant, including all dummies in the model.

β_2 is the slope of the dependent variable, namely, household consumption expenditures. It represents the expected annual percentage change in internet usage growth per unit change in household consumption expenditures given that other regressors are constant, including all dummies in the model.

β_3 is the slope of the household savings rate, which is a dependent variable. It represents the expected annual percentage change in internet usage growth per percentage change in the household savings rate given that other regressors are constant, including all dummies in the model.

β_4 is the slope of the proportion of the elderly population, which is a dependent variable. It represents the expected annual percentage change in internet usage growth per percentage change in the elderly population given that other regressors are constant, including all dummies in the model.

β_5 is the slope of the proportion the population with a college education. It represents the expected annual percentage change in internet usage growth per percentage change in the college educated population given that other regressors are constant, including all dummies in the model.

β_6 is the slope of the proportion of cable TV subscribers. It represents the expected annual percentage change in internet usage growth per percentage change in the proportion of cable TV subscribers given that other regressors are constant, including all dummies in the model.

β_7 is the slope of the dependent variable of the ownership rate of mobile phones. It represents the expected annual percentage change in internet usage growth per unit change in mobile phone ownership given that other regressors are constant, including all dummies in the model.

β_8 is the slope of the ownership rate of computers among households. It represents the expected annual percentage change in internet usage growth per percentage change in the computer ownership rate at the household level given that other regressors are constant, including all dummies in the model. Negative/positive values of β_1, β_2, β_3, β_4, β_5, β_6, β_7, *and* β_8 indicate that the internet usage growth rate decreases or increases by β_1, β_2, β_3, β_4, β_5, β_6, β_7, *and* β_8 if the corresponding regressor increases by one percentage unit.

4 Results

Table 3 reports the LSDV estimates for internet usage. The results of the table above revealed that the F-value of 90.353 was statistically high suggesting that the overall model was a good fit. The R-squared value of 0.932 was also high, which indicated that 93.2% of the total variation was accounted for by the independent variables included in the model. The Durbin-Watson test was used to assess the serial correlation, and the value was 1.728.

Again, all intercept coefficients displayed positive signs. Overall, the differential time coefficients that are statistically significant include those belonging to the college educated population, cable TV subscribers, mobile phone subscribers, and the computer ownership rate in households.

4.1 Between-group Variation

We observe that the intercept of the regression, which represents the between-group effect for Taipei City (the omitted variable), is -0.223 and is statistically significant at a p value of 0.003.

The coefficient for the dummy variable for New Taipei City is 0.201, and it is significant at a p value of <0.001. The actual group effects for New Taipei city is calculated as -0.223+0.201 = -0.022.

The coefficients for the dummy variables that represent the remaining cities—New Taipei City, Taoyuan City, ..., and Lienchiang County are all statistically significant at a p value of < 0.001. As shown in Table 4, their between-group effects can be considered identical to those for Taipei City (-0.223).

The results indicate that self-governing administrative units have differences. Nine self-governing administrative units are similar to Taipei City in terms of internet usage growth trends, and some are different, which indicates that future efforts to improve internet usage need to be tailored to local conditions.

4.2 Temporal Variation

The temporal variations in the panel analysis results suggest that the proportion of college educated people in the population, the proportion of cable TV subscribers, the proportion of mobile phone subscribers and the proportion of computers among households are significant factors related to generational transitions in internet usage. The results derived with the empirical calculation (Table 3) show that for eight independent variables, four variables are significant. The coefficient of the proportion of the college educated population is 1.443, indicating that every 1% increase in the population with a college degree is associated with an increase in internet usage of 144.3%, and the coefficient of the proportion of cable TV subscribers is 0.167, indicating that every 1% increase in cable TV users can increase internet usage by 16.7%. The coefficient of the proportion of mobile phone subscribers is 0.042, indicating that every 1% increase in mobile phone users can increase internet usage by 4.2% and the coefficient of the proportion of computers among households is -0.064, indicating that every 1% increase in computers among households can lead to a 6.4% decrease in internet usage.

The results indicate that cable and mobile operators both have a positive correlation with the growth trend of internet usage, and a greater proportion of the population with a college degree or above, has a positive correlation with the growth trend of internet usage. Importantly, internet usage has a negative relation with the ratio of computers among households.

Table 3. LSDV regression results for internet usage

	Coefficients	Standard error	t	Pr(>|t|)	Signif.
Intercept	-.223	.074	-2.999	.003	**
New Taipei City	.201	.017	11.914	<.001	***
Taoyuan City	.234	.017	14.158	<.001	***
Taichung City	.200	.016	12.202	<.001	***
Tainan City	.185	.025	7.440	<.001	***
Kaohsiung City	.183	.021	8.687	<.001	***
Yilan County	.272	.032	8.533	<.001	***
Hsinchu County	.185	.016	11.926	<.001	***
Miaoli County	.255	.030	8.353	<.001	***
Changhua County	.275	.033	8.248	<.001	***
Nantou County	.290	.038	7.720	<.001	***
Yunlin County	.301	.044	6.911	<.001	***
Chiayi County	.302	.048	6.256	.003	**
Pingtung County	.282	.037	7.544	<.001	***
Taitung County	.246	.038	6.399	<.001	***
Hualien County	.383	.043	8.865	<.001	***
Keelung City	.291	.035	8.271	<.001	***
Hsinchu City	.250	.026	9.686	<.001	***
Chiayi City	.148	.014	10.851	<.001	***
Penghu County	.162	.021	7.775	<.001	***
Kinmen County	.143	.024	6.029	<.001	***
Lienchiang County	.194	.021	9.156	<.001	***
Low-income families ratio	-.005	.005	-1.014	.312	
Household consumption expenditure	4.205E-10	.000	.007	.995	
Household saving rate	-.069	.061	-1.143	.255	
Ratio of elderly population	.336	.191	1.759	.080	
Ratio of the college educated population	1.443	.122	11.846	<.001	***
Cable TV subscriber ratio	.167	.044	3.827	<.001	***
Mobile phone household ownership rate	.042	.020	2.080	.039	*
Computer ownership rate in households	-.064	.022	-2.912	.004	**

R squared =.932, adjusted R squared =.922, ***p<0.001, **p<0.01, *p<0.05

5 Conclusion

Numerous studies have examined whether government's investments in broadband construction can meet the actual needs of individuals who require enhanced internet usage. The findings show the importance of the digital divide in an environment where broadband infrastructure is gradually being completed and internet usage is improving through policies that are in line with local characteristics.

A survey by [26] in North Carolina stated that, considering a policy of universal high speed wired broadband service, uniform adoption is unlikely to lead to universal adoption. Instead, the policy would support many households that already have internet access and that would not change their usage pattern; moreover, in many regions, this approach would be prohibitively costly, even if very generous estimates of the generated consumer surplus were assumed. Despite the government spending to build broadband in developed countries, a fully fair price mechanism may not meet the needs of local conditions under uncertain demand. [27] noted that even though there is competition in the market, consumers have no power to set prices for internet products and services. This will create a new digital divide in broadband usage between urban and rural areas.

This study examined panel data from 22 self-governing administrative units from 2011 to 2022. The main conclusions of the current study are as follows:

1) The estimated value of between-group effects for internet usage trend prediction is negative for all municipalities except for Taoyuan City. The three counties on the outlying islands, except for Penhu County, also had negative estimated values. All three cities except Keelung City all had negative estimated values, and Hsinchu County was the only county with negative estimated values. However, the digital gap and internet usage rates are not identical, ten administrative districts, such as Taipei City, are experiencing bottlenecks due to the closing of the digital gap and an increase in internet usage rates. It is also worth noting that municipalities, cities, outlying islands, and counties all have different results within their respective groups, which shows the need for local policy measures to improve digital division.

Table 4. Estimated values of between-group effects

City/County	Government Type	Estimated values of between-group effects	Annual percentage change in internet usage growth	Share of 2018-2022 Public subsidies (%)
Taipei City	Municipality	-	-	0
New Taipei City	Municipality	-.022	No	4.41
Taoyuan City	Municipality	.011		2.05
Taichung City	Municipality	-.023	No	1.56
Tainan City	Municipality	-.038	No	4.73
Kaohsiung City	Municipality	-.040	No	2.13
Yilan County	County	.049		4.34
Hsinchu County	County	-.038	No	5.16
Miaoli County	County	.032		8.83
Changhua County	County	.052		0.33
Nantou County	County	.067		6.62
Yunlin County	County	.078		0.31
Chiayi County	County	.079		7.12
Pingtung County	County	.059		10.25
Taitung County	County	.160		13.76
Hualien County	County	.068		13.78
Keelung City	City	.027		0
Hsinchu City	City	-.075	No	0
Chiayi City	City	-.061	No	0
Penhu County	Outlying islands	.023		8.67
Kinmen County	Outlying islands	-.080	No	4.39
Lienchiang County	Outlying islands	-.029	No	1.46

Note: The effect significantly different from that for Taipei City (at p=.05)

2) Compared with the cable TV and mobile usage rates, both have significant period effects on internet usage trend prediction that are positive. According to this result, cable operators and mobile operators are crucial for boosting internet usage and decreasing the digital divide in the future.

3) Compared to household characteristics, the ratio of the college-educated population has a significant positive effect on internet usage trend prediction. The ratio of computers among households has significant negative effects on the prediction of internet usage trends over time. This may show that with the development of the network society, the network has become a tool of life, and network equipment is no longer just a fixed desktop computer at home; rather, mobile devices such as mobile phones and tablets can also meet people's need for internet access. The economic gap involved in owning these devices will further exacerbate the digital divide.

In 2023, 87.2% of households in Taiwan had internet access, which is in line with the OECD average of 87.5%. Therefore, Taiwan and many developed countries may face similar challenges in broadband construction, such as differences in geographical conditions between cities and people's economic capabilities, in addition to relatively high internet penetration.

Are construction estimates based on central uniformity sufficient to meet local conditions? Is the one-time central government construction subsidy sufficient to enable consumers who do not currently use the internet to obtain an equitable network connection? Under the consistent telecom competition policy of the central government and the whole country, it is still worthwhile to explore more proactive policy measures and make good use of policy tools to reverse the current dis economies and address the reality of the noncompetitive environment. Future research may also consider the long-term maintenance of operations when broadband construction encounters uneconomical characteristics across regions but must meet universal service expectations.

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Biographies

Shui-Lien Chen is a Professor of Marketing in the Department of Management Sciences, Tamkang University, Taiwan. The focus of her research is on Internet marketing, marketing channels, international branding, and leisure marketing.

Chih-Jen Chen is a PhD student in the Department of Management Sciences, Tamkang University, Taiwan. His current research is focused on establishing a regulatory measurement model for telecom competition, which encompasses mobile network interconnection fees, fixed network rental fees, and circuit rental fees.

Yung-Hsin Lee is an Assistant Professor in the Department of International Business, Tamkang University, Taiwan. Teaching Economics, Statistics, and Taiwan investment in Mainland China is what he does. His current research interests involve Futures and Options, financial engineering, and investment.

Angelina Nhat Hanh Le is Associate Professor of Marketing, School of Management, University of Economics HCM City, Vietnam. Her research interests include marketing channels, Internet marketing, brand management, green marketing, and meta-analysis.