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Broadband adoption and self-employment - Evidence from the American Community Survey

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Abstract

This study examines how broadband adoption affects self-employment among married women using data from the American Community Survey (ACS) and the Federal Communications Commission (FCC). I find a positive association between broadband adoption and self-employment in both non-metro and metro areas. A one standard deviation increase in broadband adoption is associated with about a 0.33 percentage point increase in the probability of self-employment. Additional analysis suggests that broadband adoption is also associated with higher work-from-home participation and lower unemployment rates, and the results remain robust after excluding individuals who work from home. These findings suggest that improved digital connectivity may expand flexible work opportunities.

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1. Introduction

The expansion of high-speed broadband since the 2000s has made it increasingly accessible to a wider population. This technological advancement has been found to impact various economic factors, including the labor market, local economic growth, and college enrollment (Dettling et al., 2018; Kolko, 2012). For instance, Kolko (2012) showed that broadband expansion is associated with higher local economic and employment growth. Dettling et al. (2018) found that access to high-speed broadband positively affects college applications by reducing students' effort in the application process.

This study examines the association between self-employment (SE) among married women and broadband adoption. Previous research has shown that married women are more likely to be self-employed for various reasons, such as the flexibility to balance household responsibilities and the presence of young children (Cai et al., 2019). Additionally, factors such as education, age, past working experience, and psychological characteristics have been identified as strong predictors of SE (Carr, 1996). In particular, childcare responsibilities may encourage flexible work arrangements, making self-employment an attractive option for individuals seeking greater control over work schedules.

Many studies have examined the economic impacts of broadband technology. Forman et al. (2012) found that internet investment is associated with wage and employment growth in already-advanced areas. Whitacre et al. (2014) demonstrated that rural counties with high broadband adoption experienced greater income growth and lower unemployment rates. In healthcare, Hale et al. (2010) showed how broadband enables telemedicine services in rural areas. Falck et al. (2014) found that students with broadband access at home achieved higher grades. These studies collectively establish broadband as a key infrastructure component enabling economic development across multiple sectors.

Self-employment has gained increasing importance in the modern labor market. SE offers individuals the flexibility to balance work and personal life, as well as the opportunity to pursue entrepreneurial ventures (van der Zwan et al., 2016). The COVID-19 pandemic has further highlighted the significance of flexible work arrangements, as many businesses and employees have adapted to remote work to ensure continuity and safety (Brynjolfsson et al., 2020). Even before the pandemic, improved internet connectivity made it easier for individuals to engage in remote work, digital entrepreneurship, and other forms of flexible employment.

The availability and adoption of high-speed broadband may therefore play an important role in facilitating self-employment. Broadband access enables individuals to connect with clients, collaborate with colleagues, and access online resources and tools necessary for their work (Mack and Faggian, 2013). This is particularly important for self-employed individuals who rely on digital platforms to market their services, communicate with customers, and manage their businesses.

Several potential mechanisms may explain how broadband affects SE. First, broadband access lowers barriers to entry for SE by providing platforms for individuals to start and manage businesses online with minimal capital investment (Cumming and Johan, 2010). Second, high-speed internet enables more efficient communication and collaboration through videoconferencing, file sharing, and cloud-based services, making SE more feasible and productive (Dutcher, 2012). Third, broadband may increase job opportunities by connecting individuals to a wider pool of potential clients and employers, regardless of geographic location (Kuhn and Mansour, 2014). Fourth, broadband facilitates access to specialized knowledge and training through online courses and resources, enabling skill development necessary for

entrepreneurship. Fifth, reliable broadband also supports remote work arrangements, which may interact with entrepreneurial activities by expanding flexible employment opportunities.

Using data from the American Community Survey (ACS) and broadband information from the Federal Communications Commission (FCC), I examine whether broadband adoption is associated with self-employment among married women. In additional analysis, I explore potential mechanisms by examining work-from-home participation and unemployment outcomes. I also compare the results for married women with those for unmarried women to provide additional context for the role of household characteristics in shaping labor market responses to broadband adoption. The findings indicate that the adoption of high-speed broadband is positively correlated with SE for married women.

2. Data and Models

The primary data for this study are obtained from the American Community Survey (ACS) via IPUMS (Ruggles et al., 2020). The ACS is an annual survey that covers one percent of the U.S. population and collects information on various aspects, including labor force and employment, demographics, education, and migration. The main variable of interest is the subscription to high-speed broadband, which I use to measure individual adoption of high-speed broadband. To obtain a larger sample size, I pooled ACS data from 2013 to 2019. The smallest identified geographic areas in the publicly available ACS are Public Use Microdata Areas (PUMAs), which are designed to protect the confidentiality of respondents.[1] I start the analysis from 2013 to maintain a consistent PUMA boundary after 2012, and I do not use data beyond 2019 to avoid any impact from the COVID-19 pandemic.

As the self-reported broadband adoption variable in the ACS could be endogenous, I use PUMA-level broadband adoption as an instrumental variable (IV). I obtain the PUMA-level broadband data from the Federal Communications Commission (FCC), which is considered one of the highest quality datasets for broadband (Grubesic and Mack, 2015). The variable reports the share of the population with adoption of high-speed internet, and it serves as a measure of local broadband adoption. I aggregate this data from the census tract level to the PUMA level to match the geographic unit of the primary ACS data.

By combining all the data sources, the primary analytical sample is restricted to married women aged between 18 and 59, covering all 50 U.S. states at the PUMA level from 2013 to 2019.

I estimate a linear probability model (LPM) to investigate the probability of self-employment (SE) for an individual *i* living in PUMA *m* in year *t*:

$$Y_{imt} = \beta_0 + \beta_1 Broadband_{imt} + \gamma_1 X_{imt} + \gamma_2 P_{mt} + \pi_m + \varphi_{rt} + \mu_{imt} \quad (1)$$

The dependent variable Y_{imt} is a dummy variable indicating whether an individual reports being self-employed. The ACS identifies self-employment based on the respondent's class of worker, distinguishing self-employed individuals from wage and salary workers. $Broadband_{imt}$ is the main variable of interest, which equals one for high-speed broadband subscription. X_{imt} is a set of individual control variables, including age, age squared, race, education levels, and an indicator for the presence of a child under age five in the household. P_{mt} is a set of PUMA-specific control variables, including the share of the population with a bachelor's degree or above. π_m represents PUMA fixed effects, absorbing time-invariant confounders at the PUMA

[1] PUMAs are geographic units containing at least 100,000 people and are built on census tracts and counties. There are 2,351 PUMAs covering the entire United States.

level. φ_{rt} is a U.S. region by year fixed effect to capture time-variant shocks for a U.S. census region.[2] μ_{imt} is the error term. I cluster the standard errors at the PUMA level over time. This approach considers the potential correlation of observations within the same PUMA across different time points.

In additional analysis, I examine potential mechanisms by estimating models where the dependent variables include work-from-home employment and unemployment status. These variables are constructed from ACS labor market information and are used to explore whether broadband adoption may affect flexible work arrangements and labor market participation more broadly.

The self-reported high-speed broadband variable from the ACS may have measurement errors and, more importantly, is likely to be endogenous (meaning the variable may be correlated with unobserved factors affecting the outcome). It is not possible to control for all the confounders in the error term that are correlated with the main broadband treatment variable. To explore the possible causal effects, I use the FCC broadband adoption at a PUMA level for each year from 2013 to 2019 as an IV for self-reported broadband. The FCC broadband adoption variable categorizes the number of connections per 1,000 households into six groups: zero if no connections, one if connections are greater than zero and lower than 200, two if connections are greater than 200 and lower than 400, three if connections are greater than 400 and lower than 600, four if connections are greater than 600 and lower than 800, and five if connections are greater than 800. Although there are only six categories in the original FCC census tract data, this variable becomes a quasi-continuous variable ranging from zero to five after being aggregated to a PUMA level using the average value at the census tract level.

This IV may satisfy the relevance and exclusion requirements. For the relevance requirement, I use the first-stage IV results to confirm that the endogenous broadband variable is strongly correlated with the instrument with a correct sign. Despite being close to the conventional threshold, the first-stage F-statistic for the non-metro sample still exceeds the standard rule-of-thumb value of 10, indicating that the instrument remains sufficiently relevant. Although I cannot directly test the exclusion requirement, I argue that since an individual only lives in a small part of a PUMA, the PUMA-level broadband adoption may not directly affect an individual's SE decision. Although the IV approach addresses endogeneity concerns, some limitations remain. First, while PUMA-level broadband adoption likely satisfies the exclusion restriction by not directly affecting individual SE decisions, spillover effects may exist if economic activity within a PUMA has both regional broadband adoption and individual employment effects. Second, our instrument may capture other PUMA-level characteristics correlated with both broadband adoption and SE propensity despite our inclusion of PUMA fixed effects and region-by-year interactions. Third, the categorical nature of the original FCC data, even when aggregated to a continuous measure, may not fully capture the variation in broadband quality and reliability that could influence SE decisions. Finally, PUMA may be too large to precisely measure the exposure to high-speed broadband at a household level.

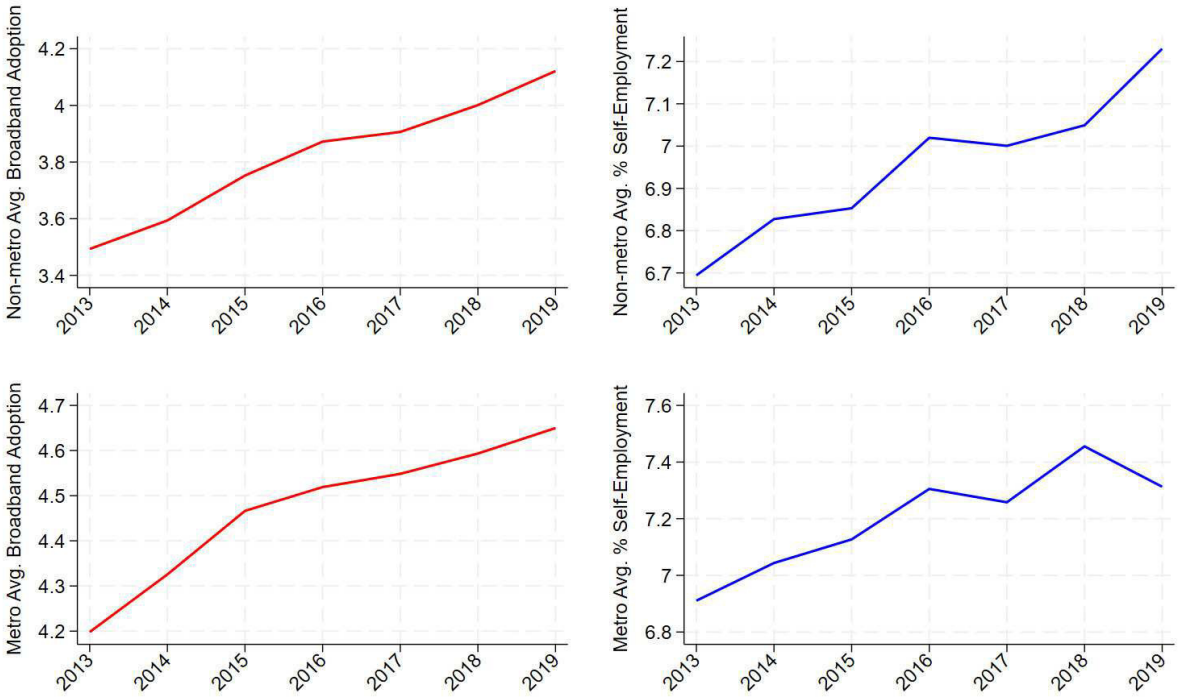
3. Results

Figure 1 shows broadband adoption (red lines, left panels) and self-employment rates (blue lines, right panels) from 2013–2019, comparing non-metro areas (top) and metro areas (bottom). Both regions show steady increases in broadband adoption with corresponding rises in

[2] The four U.S. Census regions are the Northeast, Midwest, South, and West.

self-employment, though metro areas maintain consistently higher levels of both measures throughout the period.

Figure 1 Broadband Adoption and Self-Employment Rates 2013-2019



Notes: The sample includes the years 2013-2019 and 2,351 ACS Public Use Microdata Areas (PUMAs) covering the 50 U.S. states and District of Columbia. Red lines (left panels) show broadband adoption rates and blue lines (right panels) show self-employment rates. The top two figures show the non-metro sample, and the bottom two figures show the metro sample.

Table 1 provides descriptive statistics for the key variables used in the analysis, separated by non-metro (Panel A) and metro areas (Panel B). The average self-employment rate is 7 percent in non-metro areas and 8 percent in metro areas. The ACS high-speed broadband adoption rate is lower in non-metro areas (58 percent) compared to metro areas (70 percent). Similarly, the PUMA-level broadband adoption measure is lower in non-metro areas (3.82) than in metro areas (4.47).

Table 1 Descriptive Statistics

	Mean	Std. Dev	Min	Max
Panel A: Non-metro				
Self-Employed	0.07	0.26	0	1
Unemployed	0.03	0.16	0	1
ACS High-speed broadband adoption	0.58	0.49	0	1
PUMA-level broadband adoption	3.82	0.52	1.84	5
Age	42.8	10.61	18	59
Age square	1944.53	887.57	324	3481
Small child under 5 presence	0.19	0.39	0	1
PUMA-level share of bachelor	20.04	6.78	5.83	63.59
Panel B: Metro				
Self-Employed	0.08	0.26	0	1
Unemployed	0.03	0.17	0	1
ACS High-speed broadband adoption	0.70	0.46	0	1
PUMA-level broadband adoption	4.47	0.48	1.44	5
Age	42.61	10.06	18	59
Age square	1917.21	847.59	324	3481
Small child under 5 presence	0.21	0.41	0	1
PUMA-level share of bachelor	33.43	15.21	1.81	88.52

Notes: The sample includes the years 2013-2019 and 2,351 ACS Public Use Microdata Areas (PUMAs) covering the 50 U.S. states and District of Columbia. There are 751,898 observations in non-metro sample and 2,351,531 observations in metro sample.

Table 2 presents the effects of high-speed broadband adoption on self-employment using the ACS broadband adoption variable. Panel A reports the results for non-metro areas, while Panel B reports the results for metro areas. In both panels, broadband adoption has a positive and statistically significant effect on self-employment. For non-metro areas, broadband adoption increases the probability of self-employment by 0.68 percentage points, while in metro areas the estimated effect is 0.72 percentage points. The coefficient on the indicator for the presence of a child under age five is also positive and statistically significant in both samples, consistent with the view that childcare responsibilities may increase the value of flexible work arrangements such as self-employment.

Table 2 Effects of Adoption of High-Speed Broadband on Self-Employment

	(1) OLS
Panel A: Non-metro	
ACS high-speed broadband adoption	0.0068***
	(0.0009)
Age	0.0057***
	(0.0003)
Age squared	-0.0001***
	(0.0000)
Small child under 5 presence	0.0102***
	(0.0013)
PUMA % college graduates	-0.0002
	(0.0002)
Panel B: Metro	
ACS high-speed broadband adoption	0.0072***
	(0.0006)
Age	0.0065***
	(0.0002)
Age squared	-0.0001***
	(0.0000)
Small child under 5 presence	0.0029***
	(0.0006)
PUMA % college graduates	0.0001
	(0.0001)
PUMA FE	Yes
Region*Year FE	Yes
Control Variables	Yes
Clustered std. err.	PUMA

Notes: * p<0.1, ** p<0.05, and *** p<0.01. The dependent variable is a dummy equal to one for self-employed. Additional controls not reported in the table include dummies for education level, field of study, and race. All samples are restricted to married females age between 18 and 59 and residing in non-metro areas for Panel A, and in metro areas for Panel B.

To provide additional context for the magnitude of these estimates, I interpret the coefficients using the descriptive statistics reported in Table 1. In non-metro areas, the standard deviation of broadband adoption is 0.49, and the estimated coefficient is 0.0068, implying that a one standard deviation increase in broadband adoption is associated with an increase of approximately 0.0033, or 0.33 percentage points, in the probability of self-employment. Relative to the mean self-employment rate of 0.07, this corresponds to approximately a 4.8 percent increase. In metro areas, the corresponding calculation is $0.0072 \times 0.46 = 0.0033$, again about 0.33 percentage points, which corresponds to roughly a 4.1 percent increase relative to the mean self-employment rate of 0.08.

Table 3 presents the IV estimates using PUMA-level broadband adoption as an instrument for the ACS broadband adoption variable. The first-stage results show that PUMA-level broadband adoption is a strong predictor of the ACS broadband adoption variable, with F-statistics of 10.67 for non-metro areas and 190 for metro areas, indicating the relevance of the instrument. The second-stage results show that broadband adoption has a positive and statistically significant effect on self-employment in both samples.

Table 3 Effects of Adoption of High-Speed Broadband on Self-Employment using IV

	(1)
	SE
Panel A: Non-metro	
First-stage	
ACS Broadband Adoption	0.0302***
	(0.0092)
F-stats	10.67
Second stage	
ACS Broadband Adoption	0.2653**
	(0.1243)
Observations	751,898
Panel B: Metro	
First-stage	
ACS Broadband Adoption	0.0793***
	(0.0058)
F-stats	190
Second stage	
ACS Broadband Adoption	0.0350**
	(0.0172)
Observations	2,351,531
PUMA FE	Yes
Region*Year FE	Yes
Control Variables	Yes
Cluster	PUMA

Notes: * p<0.1, ** p<0.05, and *** p<0.01. The dependent variable is a dummy equal to one for self-employed. Additional controls not reported in the table include age, age squared, dummies for education level, dummies for field of study, dummies for race groups, and share of bachelor's degree or above at a PUMA level. All samples are restricted to married females age between 18 and 59 and residing in non-metro areas for Panel A, and in metro areas for Panel B.

The IV estimate is substantially larger in non-metro areas than in metro areas, and it is also larger relative to the corresponding OLS estimate. One possible explanation is that the publicly available ACS data identify geographic location only at the PUMA level, which covers populations of at least 100,000 residents. This geographic aggregation may limit the ability to capture more localized broadband variation, particularly in rural areas where broadband availability can vary substantially within a PUMA.

To provide additional context for the population studied in this paper, I estimate the same regression models for unmarried women, and the results are reported in Appendix Table A1. The estimated effects of broadband adoption for unmarried women are generally smaller and statistically insignificant, suggesting that broadband adoption may be particularly relevant for married women who may face stronger household responsibilities and therefore value flexible work arrangements.

Finally, I explore potential mechanisms through which broadband adoption may influence labor market outcomes. Appendix Table A2 reports results for three related outcomes: work-from-home employment, unemployment, and self-employment excluding individuals who report working from home. The results show that broadband adoption is positively associated with work-from-home employment and negatively associated with unemployment. In addition, when individuals who work from home are excluded from the sample, broadband adoption continues to have a positive and statistically significant association with self-employment. These findings suggest that improved digital connectivity may expand flexible work opportunities more broadly while also supporting entrepreneurial activities.

Overall, the results indicate that the adoption of high-speed broadband plays an important role in promoting self-employment. The findings highlight the potential importance of digital infrastructure in supporting entrepreneurship and flexible work arrangements in both non-metro and metro areas.

4. Summary and Concluding Remarks

This study examines the relationship between high-speed broadband adoption and self-employment among married women in the United States. Using ACS and FCC data from 2013 to 2019, I find that broadband adoption is positively associated with self-employment in both non-metro and metro areas. A one standard deviation increase in broadband adoption is associated with about a 0.33 percentage point increase in self-employment, or roughly a 4 to 5 percent increase relative to the sample mean.

Additional analysis suggests that broadband adoption is also associated with higher work-from-home participation and lower unemployment. The positive association with self-employment remains after excluding individuals who report working from home, indicating that the main result is not driven solely by remote wage employment.

One limitation of this study is that the publicly available ACS identifies location only at the PUMA level, which may be too coarse to capture localized broadband variation, especially in rural areas. Future research using restricted-access ACS data through the Federal Statistical Research Data Centers (FSRDC) could identify smaller geographic units and allow construction of more precise local broadband measures and stronger instruments. Overall, the findings highlight the importance of digital connectivity in supporting flexible work arrangements and entrepreneurship.

Future research should also explore several directions: (1) investigating how the COVID-19 pandemic has altered the relationship between broadband and SE; (2) examining heterogeneous effects across different demographic groups and business sectors; (3) analyzing how specific broadband characteristics (speed, reliability, affordability) differentially affect entrepreneurial outcomes; and (4) exploring the long-term sustainability of broadband-enabled businesses compared to traditional enterprises.

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Table A1 Effects of Adoption of High-Speed Broadband on Self-Employment for Unmarried Women

	(1) **OLS**	(1) **IV**
Panel A: Non-metro		
ACS high-speed broadband adoption	0.0010	-0.0062
	(0.0008)	(0.0688)
Panel B: Metro		
ACS high-speed broadband adoption	0.0042***	0.0125
	(0.0005)	(0.0112)

Notes: * p<0.1, ** p<0.05, and *** p<0.01. The dependent variable is a dummy equal to one for self-employed. Additional controls not reported in the table include dummies for education level, field of study, and race. All samples are restricted to unmarried females age between 18 and 59 and residing in non-metro areas for Panel A, and in metro areas for Panel B.

Table A2 Potential Mechanisms

	(1) WFH	(2) Unemployed	(3) SE excluding WFH
Panel A: Non-metro			
ACS high-speed broadband adoption	0.0079***	-0.0053***	0.0036***
	(0.0006)	(0.0007)	(0.0008)
N	751,898	751,898	724,396
Panel B: Metro			
ACS high-speed broadband adoption	0.0089***	-0.0068***	0.0042***
	(0.0004)	(0.0005)	(0.0006)
N	2,351,531	2,351,531	2,242,605

Notes: * p<0.1, ** p<0.05, and *** p<0.01. The dependent variable is a dummy equal to one for work-from-home in column (1), unemployed in column (2). The dependent variable is a dummy equal to one for self-employed in column (3), but excluding work-from-home sample. Additional controls not reported in the table include dummies for education level, field of study, and race. All samples are restricted to married females age between 18 and 59 and residing in non-metro areas for Panel A, and in metro areas for Panel B.