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Disparate Impacts of Broadband on Women and Minorities: The Case of Broadband in the U.S.

By Mark A. Jamison and Peter Wang[†]

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Abstract We examine broadband's impacts on entrepreneurship, income, and employment in general and separately by gender and for whites versus minorities in the U.S. for 2000 – 2019. Using Current Population Surveys and matching, we find that broadband access significantly impacted the decision to be self-employed until at least 2012. Broadband access also reduced unemployment and increased earnings. It generally benefitted women and minorities more than men and whites, but not always. Broadband was particularly effective for minority males and females during the years up to and immediately following the Great Recession. These findings are consistent with the idea that broadband may dampen gender and racial bias. The effects of broadband generally diminish as adoption increases, consistent with the belief that late adopters benefit less than early adopters.

Keywords: broadband; entrepreneurship; discrimination; income; unemployment

JEL codes: L86, L26, J71, L53

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Introduction

Digitization of markets has changed nearly every aspect of the economy in the past twenty years. Nowadays it is hard to imagine how people's lives would be without the internet and online platforms accessed through broadband¹ connections, and how people would work without tools such as email, video conferencing, and search.

Adoption of broadband in the U.S. jumped from around 5% in 2000 to about 85% in 2019. (See Figure 1) This rise enabled the emergence of the digital economy, where big technology firms such as Alphabet, Amazon, Apple, and Meta have joined the ranks of Fortune 500 companies. The introduction of the iPhone led to the proliferation of mobile digital platforms, the app economy, and many platforms in the gig economy, such as Uber. Opportunities appear abundant in the digital space, such that small entrepreneurs can set up websites using Shopify, sell products on Amazon, raise capital on GoFundMe, and advertise with Alphabet or Meta with little technical assistance and minimal upfront financing. Furthermore people use broadband to search for employment and to work from home.

Only limited research has been done on the extent to which broadband affects entrepreneurship,² especially for traditionally marginalized groups, such as minority and female entrepreneurs. Shideler and Badasyan (2012) noted broadband positively impacts small and medium sized enterprise (SME) growth in the U.S. in the manufacturing sector and negatively impacts SME growth in the finance and insurance sector. Audretsch *et al.* (2015) found that broadband influences new entrepreneurial activity in high technology and consumer services industries in Germany. Kim and Orazem (2017) found that broadband made a positive impact on new firm location in rural areas of Iowa and North Carolina. Conroy and Low (2021) found that broadband positively impacted new business activity in rural areas, especially in more remote locations and women-led businesses.

Understanding these impacts requires knowledge of the underlying mechanisms. Katz (2012) explains that broadband affects economic development through four avenues: (1) the construction of broadband networks; (2) improved business productivity; (3) higher consumer incomes; and (4) increased consumer surplus. Gillett *et al.* (2006) hold that the impact of broadband penetration on economic development is not monotonic. More specifically, they state that the average and marginal impacts decline as adoption

¹ We define broadband as any high-speed internet access at home using cable, digital subscriber line (DSL), fiber optics, mobile data, or satellite.

² We define entrepreneurship as self-employment with either incorporated or unincorporated businesses.

expands “because broadband will be adopted (...) first by those who get the greatest benefit (while) late adopters (...) will realize a lesser benefit.”

Regarding effects of broadband on women and minority entrepreneurs, economic theory tells us that if there is gender or racial discrimination, it should be lower in instances where costs of discrimination are higher (or benefits lower), or when the subjects of discrimination can find means for bypassing persecutors’ (the persons doing the discrimination) suppression mechanisms. For example, a persecutor wanting to avoid doing business with racial minorities would find it less costly to know the race of a local entrepreneur with a brick-and-mortar store than the race of an entrepreneur that sells retail on Shopify or eBay.

We add to the literature on the effects of home or personal broadband on entrepreneurship by testing whether the use of such broadband by entrepreneurs enables women and minorities to obtain greater economic success relative to other groups, namely males and Caucasians.³ We also test whether this effect changes over time, perhaps because impacts are lower for late adopters than for early adopters as argued by Gillett *et al.* (2006). Our research uses a richer database than has been used before – the US Census Bureau American Community Survey (ACS) from 2000 through 2019. This data allows us to examine broadband effects at the household level, to develop a matching model that enables us to examine gender and racial differences, and to study how the effects of broadband change over time. We find that broadband induced more entrepreneurship in general, from 2000 to at least 2012 than in later years. Broadband also facilitated the growth of small businesses for minorities, as indicated by a shift in business types from unincorporated sole proprietorships to incorporated businesses for these groups. Generally, businesses adopt more complex legal structures, such as incorporation, as they grow. We also examine whether these effects extend to employment. We find that broadband access significantly decreased the likelihood of unemployment for all groups coming out of the 2007-2009 Great Recession. However, the beneficial effects of reducing unemployment for minorities started before the Great Recession. Further evidence points to broadband having had real impacts on earnings of wage earners and income of entrepreneurs alike during the same period 2000 through 2012.

³ The ACS indicates whether the person responding to the survey has broadband as a fixed service at home, via mobile broadband, or both. We do not know whether the entrepreneurs have broadband at their business location if that location is somewhere other than their home.

We find that these effects of broadband on entrepreneurship, unemployment and income diminish as the technology becomes more prevalent, especially in the period from 2013 through 2019. However, broadband's impact on the economy did not disappear: access to broadband is associated with a higher likelihood of the person responding to the survey having more than one job. Our results find greater benefits of broadband in its early years, perhaps implying that policies intended to assist women and minorities, such as are targeted in the Infrastructure Investment and Jobs Act,⁴ should focus on early adoption phases of emerging technologies, perhaps such as 5G and artificial intelligence.

Definitions of Entrepreneurship and Broadband

Broadband technologies and speed availability have changed over time. Early internet access was through low-bandwidth dial-up technologies and progressed to high-bandwidth fiber optics. (Katz 2016) Reflective of this evolution, we define broadband as any form of internet access that is faster than dial-up. This includes fixed broadband using digital subscriber line (DSL), cable modems, and fiber-optics, as well as satellite and mobile broadband. Some researchers focus on fixed broadband. But in recent years, many families, particularly minorities (Black and Hispanic), have favored mobile broadband over fixed (Pew Research 2021). We do not wish to falsely identify their situations as not using broadband by excluding mobile from our research.

Our approach may include broadband that is not used for business purposes. It may be true that an entrepreneur never works from home and so never uses a home connection to fixed broadband for business purposes. It may also be true that if the entrepreneur has a personal wireless broadband device, that it is never used for business purposes. These are likely rare cases, so we expect both home fixed broadband and personal wireless broadband to have business impacts.

There are many definitions of entrepreneurship. We adopt the most widely used definition, that of self-employment. Self-employment is further broken down into two categories, incorporated and unincorporated. Given the distribution of family income of these entrepreneurs of either definition, we take them to be small business owners. Other scholars, such as Fairlie (2013, 2021), use the same definition of entrepreneurship that we do. Based on this definition, entrepreneurship has trended slightly downwards over the past two decades. Within groups, white male entrepreneurship experienced the

⁴ Infrastructure Investment and Jobs Act, Public Law No: 117-58, 2021. Available at <https://www.congress.gov/bill/117th-congress/house-bill/3684/text>.

most severe downward trend, while white female entrepreneurship remained constant. Minority entrepreneurship experienced somewhat of a rising trend. (See Figure 2) These data imply that the racial and gender composition of entrepreneurs in the United States has been tilting towards minorities and women.

Literature Review

Information and communications technologies (ICT) are often considered to be general-purpose technologies, meaning that they broadly affect the economy. Changes in ICT affect business decisions on outsourcing versus inhouse production (Abramovsky and Griffith 2006), location of production and work (Kim and Orazem 2017), and which industries and types of works are productive (Katz 2012). Broadband, with faster bandwidth therefore allowing the acceleration of the proliferation of things like websites, search engines, cloud computing, web hosting, smartphones, and mobile applications, accelerates the changes in who gets to explore and engage in these employment and entrepreneurial activities. The limited literature in this area includes Alderete (2019) who, in a cross-country study, found that mobile broadband has a positive impact on entrepreneurship, and Hasbi (2020), who finds a prevalence of entrepreneurship in French municipalities with very high-speed broadband.

Some literature examines whether broadband complements skilled labor or unskilled labor (Akerman, Gaarder and Mogstad 2015). Bauer (2018) provides a survey on this topic. Jayakar and Park (2013) found that broadband availability lowers unemployment rates. Lobo et. al. (2020), conclude that unemployment rates in Tennessee are about 0.26 percent lower in counties with higher speeds. Fairlie (2013) found that slack labor markets increase entrepreneurship and then postulates that the Great Recession increased entrepreneurship out of necessity since unemployment was high.

Frameworks for Technology and Differential Impacts

This section discusses the theory as to why home broadband access might impact entrepreneurship, unemployment, and income; how these impacts might differ across gender and racial groups; and how they might vary over time.

E-Commerce increases the proportions of anonymous or nearly anonymous transactions, i.e., interchanges conducted by people who do not know each other and never physically meet or even speak. Thus, doing business, or screening job candidates via broadband might raise the cost of discrimination

because, absent being able to discriminate based on knowing people's names (Bernard 2016), discriminators must go to extra effort to know the races or genders of people they interact with. Further, for discrimination to have an effect, it must withhold something from the persons subject to discrimination. Also, if broadband creates new opportunities to be an entrepreneur, people normally subject to workplace discrimination might find new economic opportunities in self-employment.

We extend the Evans and Jovanovic (1989) examination of employment and liquidity-constrained self-employment with at least one significant difference: They assumed that an individual chooses between entrepreneurship and employment. We observe in our data that some people choose both entrepreneurship and employment, while others choose only one or choose none. We assume that individuals choose how to allocate time and energy, \bar{h} , across their entrepreneurship, employment, and reservation opportunities to maximize income, all other things being equal. \bar{h} is the fixed amount of time and energy (hereafter, time) each individual has to devote to income generating activities, which for simplicity we assume is uniform across individuals.

We define earnings in liquidity-constrained self-employment in period $t = [1, \dots, T]$ as $Y_{ijt}^{SE} = \theta_{ij}\pi_{ij}^x g(h^{SE}, k)\varepsilon_{ijt} + r(z_{ijt} - k)$, where $\theta_{ij} > 0$ is entrepreneurial ability, which we assume is constant over time, r is *one plus* the fixed rate of interest, $z_{ijt} \geq 0$ is the entrepreneurs' beginning-of-period wealth, $k \geq 0$ is the uniform amount of per period capital necessary for the business, $h^{SE} = [0, \bar{h}]$ is the amount of time that the individual devotes to self-employment, and $g(h^{SE}, k)$ is the productivity of time and capital. $g(0, k) = 0$ and $\frac{\partial g}{\partial h^{SE}} > 0$. $\pi_{ijt}^x > 0$ is the impact of the entrepreneur's broadband choice, where $x = \{A, B\}$ denotes whether there is home or mobile broadband (B) or not (A). $i = \{w, m\}$ denotes whether the person is white (w) or a minority (m). $j = \{m, f\}$ denotes male (m) or female (f). ε_{ijt} is the random term. π_{ij}^x might vary by gender and racial groups because of differences in discrimination or other reasons.

Regarding wages, we also extend Evans and Jovanovic (1989); individuals can obtain an employment earning of $Y_{ijt}^w = w_{ijt}(h^w, x)$, where $h^w = [0, \bar{h}]$ is the amount of time the person devotes to earning income from wages. $w_{ijt}(0, x)$ and $\frac{\partial w_{ijt}}{\partial h^{SE}} > 0$.

Returning to the issue of how individuals choose to allocate \bar{h} across the competing opportunities, let $Y_{ijt} \equiv Y_{ijt}^{SE} + Y_{ijt}^w + Y_{ijt}^R$, where $Y_{ijt}^R \geq 0$ is the reserve value of time, $h^R = [0, \bar{h}]$ is the amount of time not spent in entrepreneurship or employment, and $Y_{ijt}^R|_{h^R=0} = 0$. $T(\bar{h}) = \{h^{SE}, h^w, h^R\}$ is a partitioning of \bar{h} across the competing uses, such that $h^{SE} + h^w + h^R = \bar{h}$. Let $\tau(\bar{h})$ represent the income maximizing partitioning of time for an individual, i.e., $Y_{ijt}(\tau(\bar{h})) \geq Y_{ijt}(T(\bar{h})) \forall T(\bar{h})$.⁵ The person relies only on entrepreneurship if $\tau(\bar{h}) = \{h^{SE} > 0, 0, h^R\}$, only on employment if $\tau(\bar{h}) = \{0, h^w > 0, h^R\}$, or on both if $\tau(\bar{h}) = \{h^{SE} > 0, h^w > 0, h^R\}$, and is unemployed if $\tau(\bar{h}) = \{0, 0, \bar{h}\}$.

We now turn our attention to how broadband affects these choices. Focusing first on entrepreneurship, it is reasonable to believe that having broadband is at least as good as having none for entrepreneurs, i.e., $\pi_{ijt}^B \geq \pi_{ijt}^A \Rightarrow Y_{ijt}^{SE}|_{x=B} \geq Y_{ijt}^{SE}|_{x=A}$, which means broadband would at least weakly increase the likelihood of observing entrepreneurship all other things being equal. From Gillett *et al.* (2006), we expect if $\pi_{ijt}^B - \pi_{ijt}^A > 0$ for some t , $\pi_{ijt}^B - \pi_{ijt}^A$ should approach zero as adoption approaches 100 percent.

But broadband also might affect a person's employment. Our data considers someone as unemployed if the person is looking for a job and is neither employed nor an entrepreneur. From the perspective of a matching model of unemployment, if broadband at least weakly increases the likelihood of matches by presenting job seekers with a higher number of postings and employers with more potential job candidates, the likelihood of quality matches is also weakly higher, with an impact on wages as well, i.e., $w_{ijt}(h^w, B) \geq w_{ijt}(h^w, A)$.

Thus when examining our empirical results, we must consider how broadband affects entrepreneurship and affects employment relative to each other. If broadband increases entrepreneurship, we can conclude that broadband increases the profitability of entrepreneurship relative to that of employment, but we cannot say that broadband had no influence on the profitability of employment. This holds if we observe broadband increasing entrepreneurship and lowering unemployment as we cannot rule out that broadband enabled both self-employment and having a job. But if we observe broadband increasing (conversely, lowering) entrepreneurship and not affecting unemployment, we can conclude that

⁵ For ease of exposition we assume that each individual has only one $\tau(\bar{h})$, but that assumption is not important for our conclusions.

broadband enables people to shift time from (conversely, towards) employment, their reservation activities, or both and towards (conversely, away from) self-employment. Similarly, if we observe broadband decreasing unemployment, but not increasing entrepreneurship, we can conclude that it has had a greater positive impact on the profitability of employment relative to that of entrepreneurship.

We now turn our attention to how broadband might alter the effects of gender discrimination, racial discrimination, or both. If there is discrimination against minorities and women as entrepreneurs, then $\pi_{wjt}^A \geq \pi_{mjt}^A$ and $\pi_{imt}^A \geq \pi_{ift}^A$, implying $Y_{wjt}^{SE}|_{x=A} \geq Y_{mjt}^{SE}|_{x=A}$ and $Y_{imt}^{SE}|_{x=A} \geq Y_{ift}^{SE}|_{x=A}$, unless the differences are caused by θ_{ij} varying with gender, race, or both. If the anonymity that internet interactions bring can at least weakly improves minority entrepreneur earnings relative to whites, then $\pi_{mjt}^B - \pi_{mjt}^A \geq \pi_{wjt}^B - \pi_{wjt}^A$, implying $Y_{mjt}^{SE}|_{x=B} - Y_{mjt}^{SE}|_{x=A} \geq Y_{wjt}^{SE}|_{x=B} - Y_{wjt}^{SE}|_{x=A}$. If this is the case, we should observe a higher rate of entrepreneurship for minorities when they have broadband, relative to the rate of whites, all else equal. Likewise if this effect applies to females, then we would expect $\pi_{ift}^B - \pi_{ift}^A \geq \pi_{imt}^B - \pi_{imt}^A$, implying $Y_{ift}^{SE}|_{x=B} - Y_{ift}^{SE}|_{x=A} \geq Y_{imt}^{SE}|_{x=B} - Y_{imt}^{SE}|_{x=A}$. But differences in broadband penetration across genders and races also might cause differences in impacts of broadband *à la* Gillett *et al.* (2006). We address this possibility by inspecting broadband penetrations by gender and race (Figure 1) when examining our results. Finally, if we observe these differences in broadband effects and that they approach zero as broadband penetration increases, this would be evidence that entrepreneurial abilities do not measurably vary by gender or race.

However, it would be inappropriate to view broadband's effects on entrepreneurship by race and gender in isolation from its effects employment. If broadband increases entrepreneurship for females relative to males or minorities relative to whites, we can conclude that broadband increases their profitability of entrepreneurship relative to that of employment, but we cannot say that broadband had no influence on their profitability of employment. This holds if we observe broadband relatively increasing their entrepreneurship and lowering their unemployment as we cannot rule out that broadband enabled both self-employment and having a job. But if we observe broadband increasing (conversely, lowering) their entrepreneurship and not affecting their unemployment in relative terms, we can conclude that broadband enables them to shift time from (conversely, towards) employment, their reservation activities, or both and towards (conversely, away from) self-employment in relative terms. Similarly, if we observe broadband decreasing their unemployment in relative terms, but not increasing entrepreneurship, we can

conclude that it has had a greater positive impact on their profitability of employment relative to that of their entrepreneurship.

Data

We rely on the Computer and Internet Use Supplement conducted by Census Bureau Current Population Survey (CPS), sponsored by the National Telecommunications and Information Administration (NTIA). The supplement is intermittent and has reported United States household use of computers and the internet since the 1970's. CPS is primarily a survey of the labor market, and on top of basic demographic questions, asks about labor market participation, whether the respondent is self-employed, whether the business (if there is one) is incorporated or unincorporated, and occupation and industry.

Because we define broadband as above-voice-grade access, regardless of technology, the relevant CPS survey waves we use start at 2000. The Computer and Internet Use Supplement is conducted for one month in the years 2000, 2001, 2003, 2007, 2009, 2010, 2012, 2013, 2017, and 2019. Because we observe any individual's internet use only once, this precludes an analysis of new entrepreneurship formations, or employment by matching respondents across surveys. However, we can make cross-sectional comparisons, by examining, for example, the likelihood of entrepreneurship given ownership of broadband or not, conditional on all pretreatment characteristics that determine the probability of broadband ownership. The matching methodology will be described in the next section. Table 1 provides the summary statistics for our variables.

[PLACE TABLE 1 ABOUT HERE]

Figure 1 presents trends in internet adoption, for everyone, by gender, and by race. In aggregate, broadband grew from close to 5% penetration for U.S. adults in the labor force in 2000, to about 85% in 2019. Minority broadband access, henceforth only concerning Blacks and Hispanics, always lagged their white counterparts, but with the gap closing somewhat since 2013. Figure 1 omits 2011 and 2015 because we found a significant decline in broadband adoption in those years, which is neither explained in the CPS supplement nor observed in other datasets such as the FCC annual internet usage reports. Fearing this may indicate quality problems for those years that could bias our results, we drop these two data waves. Given the timing of when the Computer and Internet Use Supplement is conducted, as well as the great recession having a certain impact on entrepreneurial activities, earnings, and unemployment, we divide our analysis into three separate periods: the early years of broadband, 2000 – 2007 (also called 1st Period);

recovery from the Great Recession, 2009 – 2012 (also called 2nd Period); and broadband in recent years, 2013 – 2019 (also called 3rd Period).

[PLACE FIGURE 1 ABOUT HERE]

Figures 2 and 3 show that entrepreneurship occurs at different rates for whites and minorities and for males and females. Though on average 12.2% of the current labor force would define themselves as primarily self-employed, that rate is about 16% for white males, 9% for white females, 9% for minority males, and about 6% for minority females. Disaggregating this further, Figure 4 shows that white men's high rates of entrepreneurship in general is largely because of their high rates in agriculture/mining and construction/manufacturing (primary and secondary industries). Also, in general, minority men's higher rates of entrepreneurship relative to minority females is largely because of minority men's high rates in construction/manufacturing. These industry concentrations appear to also affect the large numbers of male entrepreneurs considering themselves "blue-collar", while almost all female entrepreneurs consider themselves white collar.

[PLACE FIGURES 2-4 ABOUT HERE]

Figure 5 shows that, although the level of entrepreneurship seems to have declined somewhat over the 20-year horizon of our analysis, there was a rise in incorporated entrepreneurship and a decline in unincorporated entrepreneurship. The rise in incorporated entrepreneurship is also more apparent in the most recent period, from 2013 to 2019.

[PLACE FIGURE 5 ABOUT HERE]

Figures 6 and 7 show employment and income by race and gender. Minorities had the highest unemployment rates and the lowest rates of working multiple jobs throughout our time period. They also had the steepest job losses during the Great Recession and the strongest recoveries. Indeed their rates converge towards the population averages in 2017-2019. White males and females have similar unemployment rates, but white males are more likely than white females to have more than one job.

[PLACE FIGURES 6-7 ABOUT HERE]

Figure 8 shows that earnings were fairly constant throughout the period but had a slight decline from the 2003 until 2012, at which point they began a slight incline. White male income was sufficiently higher than all other groups to have all other groups below average. Incorporated entrepreneurs' incomes were

higher than unincorporated throughout out period. Entrepreneurial income declined from 2000 to 2012, and then began a slight upward trend.

[PLACE FIGURE 8 ABOUT HERE]

Methodology

To assess the impact of broadband on entrepreneurship, likelihood of unemployment, and income/earnings, we use the nearest neighbor matching method proposed by Abadie & Imbens (2006). Essentially, we are interested in the “average treatment effect” of broadband access. For example, all else equal, how much more (or less) likely is someone who owns broadband to engage in small business entrepreneurship? Since broadband ownership is not randomly assigned, according to Rosenbaum and Rubin (1983, 1985), outcome needs to be independent of “treatment” conditional on a set of observable covariates:

$$(Y_i, Y_j) \perp T_i | X_i$$

In other words, the set of pretreatment observable characteristics of an individual are all that determines the probability of obtaining broadband, and conditional on those we can take treatment as essentially random. Say that for each observation i , we find at least one person in the opposite treatment group who is the closest to the individual in terms of all observable characteristics. Then, for individuals who have home high-speed internet access and otherwise, and for each sample unit i , define $j(i)$ as the match from the opposite “treatment” group, we are then interested in an average treatment effect:

$$\hat{\tau}_{ATE} = \frac{1}{n} \sum_{i=1}^n W_i (Y_i - Y_{j(i)}) - \frac{1}{n} \sum_{i=1}^n (1 - W_i) (Y_j - Y_{i(j)})$$

To summarize, nearest neighbor matching finds, for a set of covariates, the closest match from the opposite “treatment” group in terms of distance to the covariate values. Note that we are interested in the average treatment effect, instead of merely the average treatment effect on the treated, because we are not only interested in how much more likely a person with home broadband access is to become an entrepreneur, but we are also interested in how much more likely a person would become an entrepreneur who does not have home high-speed internet if he or she were given broadband access at home.

The covariates X_i we use in the model are a person's age, number of members in the household, marital status, education, Industry, occupation, region of residence, metropolitan status, and citizen status. This set of covariates is generally used in the literature as pretreatment characteristics that determine the probability of obtaining broadband⁶. The matching procedure is carried out as follows. We use one-to-one matching with replacement, as Monte Carlo simulation studies find that one-to-one matching tends to be the least biased, albeit with larger standard errors (Austin 2010). For each wave of the survey, we match exactly on a person's gender, race (White, Black, or Hispanic), and metropolitan status within the year. We then examine the quality of the match by looking at standardized differences of the covariates after matching. If any covariate's standardized difference exceeds 10%, we either set the covariate to be an exact match if it is a categorical variable or apply a binding caliper if it is continuous and repeat the process until all variables are balanced (All covariates have a standardized difference less than 10% after matching). This is done to ensure the quality of our matches while also ensuring our results are generalizable by minimizing the number of observations discarded. In most cases achieving a good balance is not difficult; we found that we did have to discard many minority male and female observations in the first period 2000 - 2003, because broadband penetration was so low for minorities in those times. We then report the average treatment effect, along with Abadie & Imben's (2011) robust standard errors. To avoid further bias introduced by using continuous variables (age and household number), we use the bias-adjusted version of the average treatment effects and enter the adjustment terms for age and household member number linearly. Tables 2 – 4 present the post-matching balance of the “treated” and “untreated” groups for each covariate and each group in each of the three periods.

[PLACE TABLES 2 - 4 ABOUT HERE]

To assure the accuracy of our results we supplement the nearest-neighbor matching results with Inverse Probability Weighting (IPW) methods, a parametric way to model the propensity of acquiring broadband. Specifically, the propensity of acquiring broadband given covariates is modeled by a logit model:

$$p(X_i) = Pr(W_i = 1|X_i)$$

With X_i 's being the same set of covariates, or pretreatment characteristics. In most cases, the true propensity score is unknown and needs to be estimated. We use the logit model to estimate the propensity score:

⁶ See for example, Alam (2019) and Fairlie (2003).

$$\hat{p}(X_i) = \frac{e^{X_i B}}{1 + e^{X_i B}}$$

The covariates are an intercept plus a person's age, number of households, marital status, education, industry, occupation, region of residence, metropolitan status, and citizen status. We also include a full set of regions times year effects. After estimating the propensity score, we use the predicted probabilities of obtaining broadband and calculate, for each observation, the inverse of the probability to weigh the observation in a Weighted Least Squares regression with the independent variable being broadband and dependent variable being the outcome of interest. Specifically, since we are interested in an average treatment effect, the weights, w_i , are:

$$w_i = \begin{cases} \frac{1}{\hat{p}(X_i)}, & d_i = 1 \\ \frac{1}{1 - \hat{p}(X_i)}, & d_i = 0 \end{cases}$$

Main Results

We begin with Table 5, which presents results for the impact of broadband on entrepreneurship and unemployment, aggregating whites, minorities, males, and females. For 2000 – 2012, broadband increased the propensity for entrepreneurship in general and incorporated businesses in particular. The effects were not present after 2013. Broadband encouraged unincorporated entrepreneurship prior to the Great Recession, but not since. Broadband decreased unemployment in all three periods we examined but had its greatest impact in the years immediately following the Great Recession.

[PLACE TABLE 5 ABOUT HERE]

We now turn our attention to Table 6, which presents results by race and gender. We begin by analyzing gender differences. White males and females have similar patterns, namely that broadband tends to encourage entrepreneurship for 2000 through 2012, but not after. The coefficients for entrepreneurship tend to be greater for white females than for white males, suggesting that it may be true that the broadband softened the effects of gender discrimination. White females are different from white males in terms of how broadband affects incorporation versus not incorporating. Broadband incited white males to convert their businesses from unincorporated to incorporated, as evidenced by the coefficients for incorporation being greater than those for entrepreneurship and the coefficients for unincorporated being negative, although rarely statistically significant. Broadband increased white women's propensity to be self-employed until 2012 for either type of legal arrangement.

[PLACE TABLE 6 ABOUT HERE]

We now examine gender effects for minorities from Table 6. Minority males and females show similar patterns, namely that broadband encouraged entrepreneurship through 2012. But in contrast with the patterns for whites, broadband impacted minority males more than it did females, as evidenced by the males' coefficients being consistently greater than those for females. The positive impact for minority females' entrepreneurship ends with the Great Recession, except for incorporated businesses. Here the coefficients imply that minority women tended to shift their businesses from unincorporated to incorporated for the years immediately following the great recession. We conclude, then, that the possible gender bias that we observe in the results for whites do not appear to exist in the results for minorities.

Now we turn our attention to differences between whites and minorities from Table 6. We begin with males. The effects of broadband on entrepreneurship are more pronounced for minority males than for white males, implying that broadband could decrease the effects of racial discrimination. This is true for entrepreneurship in general, but the reverse is true for incorporation as white males have a higher propensity to have incorporated businesses than their minority counterparts prior to 2013, although the difference declines with time. Also, while we see broadband encouraging white males to transition businesses from unincorporate to incorporated, this pattern is missing for minority males until after 2013. Indeed broadband encourages minority males to have unincorporated businesses as well as incorporated businesses until the Great Recession, at which time the propensity to form unincorporated businesses drops from being statistically significant.

The racial differences in women show some different patterns than for men. Broadband has a greater impact on minority women's propensity to be entrepreneurs than it does for white women in 2000 – 2007, but the effect reverses after the Great Recession until 2013, at which time the impact disappears for both. Minority women are more likely than white women to have unincorporated businesses until 2007, at which time the white females are more likely. The effect again disappears after 2012. On the other hand, white women are more likely to have incorporated businesses than their minority counterparts until 2013. We conclude that this evidence is consistent with broadband decreasing the effect of racial discrimination for women.

Table 6 shows for all groups that the effects of broadband drop to statistically insignificant levels after 2012. From Figure 1, broadband adoption rates tend to converge during the 2013 – 2019 time period,

reaching at least 80% for all groups. This is consistent with the hypothesis that the effects of broadband become nearly inconsequential for late adopters, at least with respect to encouraging entrepreneurship.

In summary for Table 6, the evidence for broadband helping overcome gender discrimination is present for whites, but the reverse is true for minorities. The evidence for broadband helping overcome racial discrimination is present for both males and females. But these effects largely disappear once broadband adoption reaches high levels. It might be that these differences between races and genders reflect differences in abilities, i.e., differences in θ_{ij} depending on race and/or gender. But if that were the case the differences should have persisted after 2012. That the differences disappear leads us to believe that there is no evidence supporting innate differences in broadband's impacts based on race and/or gender.

We now turn our attention to Table 7, which presents our results regarding unemployment. Negative coefficients represent decreases in unemployment rates. We do not find evidence that broadband reduces gender discrimination. Indeed for both whites and minorities, broadband tends to reduce unemployment more for males than for females. The exception is in the Adjusted column for 2009 – 2012, where minority females experience a slight greater impact than do minority males. There does appear to be evidence that broadband decreases the effects of racial bias: The impacts of broadband for minorities are consistently larger than its impacts for whites. But with respect to how effects change over time, the pattern for white males is different from all others, namely in that the effects are not statistically significant before 2008 for white males – they are statistically significant for all other groups – and the effects are statistically significant for white males after 2012, but not for any other group. Thus there is evidence for the effects of broadband becoming nearly inconsequential for late adopters, at least with respect to unemployment, except for white males. For white males, the effect appears to be the opposite, except that the coefficients for white males for 2013 – 2019 are insignificant economically.

[PLACE TABLE 7 ABOUT HERE]

Table 8 shows our findings with respect to broadband's impacts on earnings. Broadband has a statistically significant impact on earnings across our time period, but the economic effect declines with time, consistent with our findings regarding entrepreneurship and unemployment, namely that impacts are lower for late adopters than for early adopters. The gender impacts are different for whites than we saw for entrepreneurship, but consistent with what we saw for employment. With entrepreneurship (Table 6), broadband provided a larger impact for white women than for white men. The opposite is true for

earnings. This finding for earnings is inconsistent with the theory that broadband has a meaningful impact on women's ability to avoid discrimination with respect to employment earnings.

[PLACE TABLE 8 ABOUT HERE]

Another difference between earnings and self-employment for white women is that the broadband effects are higher in the years immediately following the Great Recession than before. This is inconsistent with the theory that impacts were lower for later adopters, but the Great Recession might have affected women's employment differently than it did men's employment. However, this result would be consistent with a theory that we do not test, namely that the Great Recession affected women differently than it did men. Wething (2014) finds that industries that employ women were less impacted by the Great Recession than were those that employ more men. We control for industry, but still the difference in broadband impact might result from women having greater job success than men during the Great Recession.

The pattern for gender differences for minorities is nearly the opposite the pattern for whites, except for the general decline in impacts. For minorities, broadband's impact was greater for women than for men, except in the years immediately following the great recession. This pattern is consistent with the theory that broadband weakens the effects of gender bias for minorities' earnings, but we are unable to find an explanation for why the impact was greater for minority men than for women in the years immediately following the Great Recession.

Comparing white males to minority males, and white females to minority females in Table 8, our findings are consistent with the theory that broadband helps diminish the effects of racial bias. There is a minor exception for one coefficient for minority men before the Great Recession, and for minority women the effects are lower than for white women in the years immediately following the Great Recession, but the coefficients are sufficiently close to each other be inconclusive with respect to how broadband might affect racial bias in regard to earnings.

Table 9 shows the impact of broadband on entrepreneurial income. Because of data limitations, we are unable to differentiate by race and gender. The impacts are positive and generally statistically significant. As is true for other areas of our analysis, the effects appear lower for late adopters than for early adopters, implying that current efforts to expand broadband in the US will have small impacts on entrepreneurial income.

[PLACE TABLE 9 ABOUT HERE]

Table 10 records the results for the impact of broadband on the probability of taking on more than one job. We find that broadband makes a greater difference for minorities than for whites but makes a greater difference for women than men only in racial minorities. Having broadband increases the likelihood of someone having more than one job in all three periods that we examine, with the impact of broadband being greatest in the years immediately following the Great Recession. In the years before the Great Recession, broadband's impact was statistically significant for minorities, but not for whites. In 2009-2012, broadband's impact was statistically significant for all of our groups, with the impact being least for white men and greatest for minority women. This pattern roughly held for 2013-2019, with the exception that the effects for white women were not statistically significant.

[PLACE TABLE 10 ABOUT HERE]

Significance

Figures 9-13 illustrate the statistical significance of our findings for differences between races and genders. The filled circles in each graph represents the corresponding coefficient values from the tables. The vertical lines illustrate 95% confidence intervals. Figure 9 shows that the 95% confidence intervals for broadband's effects on entrepreneurship overlap for all groups in all periods, meaning that we cannot say with 95% certainty that the coefficients are different, with the exception being minority males in 2000-2007. Figure 10 illustrates that we can be confident that broadband's impacts on white men to own incorporated businesses in 2000-2007 is greater than for other groups, and that the impacts on minority women to own incorporated businesses in 2009-2012 is less than for other groups. Otherwise, the coefficients for incorporated businesses are within each other's' 95% confidence intervals.

[PLACE FIGURES 9 AND 10 ABOUT HERE]

The pattern for unincorporated businesses in Figure 10 generally maps to the pattern for incorporated businesses in that most coefficients are within the 95% confidence intervals of other groups, with the exception being white men in 2000-2007. White women are statistically less likely to have unincorporated businesses than minority men, but not minority women.

Figure 11 provides confidence intervals for broadband's impact on unemployment. That broadband benefitted minorities more than whites is clear for 2000-2007 and for 2009-2012, with the possible exception for white males in 2009-2012, where the white male coefficient was within the confidence

intervals for both men and women minorities. By 2013-2019, the coefficients for the four groups are not statistically different.

[PLACE FIGURE 11 ABOUT HERE]

Figure 12 shows significance for earnings effects. The effect for white males is statistically higher than for the other groups in 2000-2007, but not in 2009-2012, and only higher than white women in 2013-2019. All groups are within each other's confidence intervals in 2009-2012, except for minority men, which was statistically above females, but not white males. All groups are within each other's confidence intervals in 2013-2019, except for white women, which was statistically below all others.

[PLACE FIGURE 12 ABOUT HERE]

Figure 13 shows confidence intervals for having more than one job. The groups tend to be within each other's confidence intervals, except for minority women, whose effects are statistically above those of whites in 2000-2007 and above all other groups in 2009-2012.

[PLACE FIGURE 13 ABOUT HERE]

Conclusions

We examine whether broadband helps people find ways to earn income, primarily via increasing the likelihood of entrepreneurship and reducing the likelihood of unemployment. We also study whether broadband's influences are different for whites than for minorities and different for men than for women. We find that until as late as 2012, having broadband at home led to a higher propensity to become an entrepreneur, and there is evidence that entrepreneurs with broadband tend to earn a higher income. Furthermore, broadband leads to a lower probability of unemployment and higher weekly earnings in the same period. Broadband reduced the likelihood of unemployment especially during the recovery period to the Great Recession and could have been similarly important for maintaining the level of entrepreneurship and income. Importantly, broadband tended to facilitate unincorporated sole proprietorships for minority men and women in the early years and transitioning to incorporated businesses, whereas it always facilitated incorporated entrepreneurship for white men and women. Broadband access helped reduce the likelihood of unemployment for minority men and women, even in the early years of broadband, 2000 – 2007. These beneficial effects decline over time, perhaps reflecting lower marginal impacts for late adopters.

Our results imply that early adoption of advanced ICT, particularly for traditionally marginalized households, is important. Depending on the economic conditions, broadband had implications for escaping unemployment, particularly for minorities. This could imply that government policy should be directed at promoting inclusivity in innovations.

There is still much left for future research. For one, that broadband seemed to exhibit less impact on the economic variables in question in recent years deserves more attention. One way to verify our results is by using similar variables obtainable from American Community Survey from 2013 – 2016. Also, throughout the paper we have grouped together all “high-speed” internet access, calling it broadband. More recently, we have witnessed the rise of mobile broadband and the impressive speed with which that technology has been upgraded. Future research will benefit tremendously by looking at how particular broadband technologies influence the types of entrepreneurships and employment, as well as income. Finally, Congress is now funding broadband expansion. Researchers should press government officials to provide data for assessing the impacts.

Tables and Figures

Table 1: Summary Statistics

Variable	Mean	Standard Deviation	Obs.
Age	44.180	13.160	618,549
Number Household Member	2.930	1.440	618,549
Proportion High School or Less	0.469	0.263	618,549
Proportion High School Graduate	0.282	0.450	618,549
Proportion Some College/College Graduate	0.296	0.457	618,549
Proportion Beyond College	0.347	0.476	618,549
Proportion Married	0.638	0.481	618,549
Proportion Non-citizen	0.058	0.234	618,549
Proportion in Primary Industry	0.029	0.167	618,549
Proportion in Secondary Industry	0.185	0.388	618,549
Proportion in Tertiary Industry	0.459	0.498	618,549
Proportion in Quaternary Industry	0.327	0.469	618,549
Proportion Blue Collar	0.221	0.415	618,549
Proportion in Region: Northeast	0.205	0.404	618,549
Proportion in Region: Midwest	0.196	0.397	618,549
Proportion in Region: South	0.338	0.473	618,549
Proportion in Region: West	0.261	0.439	618,549
Proportion Female	0.475	0.499	618,549
Proportion Minority (Black & Hispanic Only)	0.213	0.410	618,549
Proportion Metropolitan	0.789	0.408	618,549
Proportion Entrepreneurship	0.122	0.327	618,549
Prop. Incorporated Entrepreneurship	0.042	0.201	618,549
Prop. Unincorporated Entrepreneurship	0.080	0.271	618,549
Proportion in Unemployment	0.046	0.210	618,549
Single Adult Entrepreneur Annual Family Income	47106.710	38916.930	7,211
Weekly Earnings	940.900	667.320	130,623
Proportion more than one Job	0.0606	0.239	588,674

Statistics for U.S. adults in the labor force aged 21 – 25 in the CPS survey of Aug. '00, Sept. '01, Oct. '03, Oct. '07, Oct. '09, Oct. '12, Jul. '13, Nov. '17, and Nov. '19. Total Observation of 618,549. Income and Earnings figures in 2015 dollars.

Table 2: Balance Statistics of Main Results 2000 - 2007

	<u>White Male</u>			<u>White Female</u>			<u>Minority Male</u>			<u>Minority Female</u>		
	B	NB	Szd.	B	NB	Szd.	B	NB	Szd.	B	NB	Szd.
1. Age	43.43 (11.66)	43.90 (12.45)	-4.08	43.29 (11.38)	43.63 (12.28)	-2.95	39.10 (10.74)	39.71 (11.81)	-5.70	39.73 (10.62)	40.13 (11.60)	-3.82
2. Number Household	2.92 (1.29)	2.90 (1.36)	1.92	2.83 (1.23)	2.79 (1.29)	3.16	3.40 (1.58)	3.41 (1.72)	-0.83	3.15 (1.45)	3.18 (1.56)	-2.13
3. Highschool Grad	0.31 (0.46)	0.31 (0.46)	1.14	0.29 (0.45)	0.29 (0.45)	-0.49	0.34 (0.47)	0.33 (0.47)	2.68	0.32 (0.47)	0.31 (0.46)	1.07
4. Some College/Grad	0.28 (0.45)	0.28 (0.45)	0.69	0.32 (0.47)	0.32 (0.47)	-0.01	0.27 (0.44)	0.24 (0.42)	7.58	0.35 (0.48)	0.30 (0.46)	8.94
5. Beyond College	0.36 (0.48)	0.35 (0.48)	2.10	0.35 (0.48)	0.35 (0.48)	0.80	0.18 (0.38)	0.16 (0.37)	3.68	0.23 (0.42)	0.21 (0.41)	5.13
6. Married	0.72 (0.45)	0.71 (0.45)	2.72	0.68 (0.46)	0.67 (0.47)	4.23	0.62 (0.48)	0.62 (0.48)	0.00	0.48 (0.50)	0.48 (0.50)	0.00
7. non-citizen	0.02 (0.14)	0.02 (0.14)	0.00	0.02 (0.12)	0.02 (0.13)	-0.42	0.28 (0.45)	0.28 (0.45)	0.00	0.14 (0.35)	0.14 (0.35)	0.00
8. Secondary Industry	0.30 (0.46)	0.30 (0.46)	0.22	0.09 (0.29)	0.09 (0.29)	-0.25	0.30 (0.46)	0.31 (0.46)	-1.55	0.10 (0.30)	0.11 (0.31)	-1.24
9. Tertiary Industry	0.46 (0.50)	0.45 (0.50)	2.15	0.41 (0.49)	0.41 (0.49)	0.25	0.52 (0.50)	0.50 (0.50)	4.74	0.44 (0.50)	0.44 (0.50)	1.74
10. Quaternary Industry	0.21 (0.40)	0.21 (0.40)	-0.03	0.48 (0.50)	0.48 (0.50)	-0.10	0.16 (0.37)	0.17 (0.37)	-0.72	0.45 (0.50)	0.45 (0.50)	-0.12
11. Blue Collar	0.35 (0.48)	0.36 (0.48)	-1.60	0.06 (0.23)	0.06 (0.24)	-1.48	0.45 (0.50)	0.47 (0.50)	-4.40	0.12 (0.32)	0.12 (0.32)	0.00
12. Midwest	0.23 (0.42)	0.23 (0.42)	-0.29	0.23 (0.42)	0.23 (0.42)	-0.60	0.11 (0.32)	0.11 (0.32)	0.00	0.11 (0.32)	0.13 (0.34)	-5.69
13. South	0.29 (0.45)	0.29 (0.45)	-0.26	0.29 (0.45)	0.29 (0.45)	0.37	0.41 (0.49)	0.43 (0.49)	-2.79	0.45 (0.50)	0.46 (0.50)	-0.81
14. West	0.26 (0.44)	0.26 (0.44)	-0.05	0.25 (0.43)	0.25 (0.43)	-0.15	0.28 (0.45)	0.31 (0.46)	-7.09	0.23 (0.42)	0.25 (0.43)	-4.59

Balance table for nearest neighbor matching in the first period 2000 – 2007. B: statistics for broadband group after matching. NB: statistics for no broadband group after matching. Szd: standardized difference between broadband group and no broadband group after matching (in percentages).

Table 3: Balance Statistics of Main Results 2009 - 2012

	<u>White Male</u>			<u>White Female</u>			<u>Minority Male</u>			<u>Minority Female</u>		
	B	NB	Szd.	B	NB	Szd.	B	NB	Szd.	B	NB	Szd.
1. Age	45.39 (13.21)	45.79 (13.10)	-3.01	45.33 (12.99)	45.52 (12.90)	-1.45	40.39 (11.93)	40.66 (12.08)	-2.30	41.24 (11.77)	41.17 (12.00)	0.59
2. Number Household	2.85 (1.38)	2.74 (1.31)	8.22	2.78 (1.30)	2.69 (1.22)	6.58	3.43 (1.69)	3.25 (1.67)	10.56	3.20 (1.54)	3.07 (1.50)	8.51
3. Highschool Grad	0.29 (0.45)	0.29 (0.45)	-0.14	0.25 (0.43)	0.25 (0.43)	-0.17	0.35 (0.48)	0.34 (0.47)	1.12	0.29 (0.45)	0.29 (0.45)	0.55
4. Some College/Grad	0.28 (0.45)	0.28 (0.45)	0.29	0.33 (0.47)	0.32 (0.47)	0.24	0.25 (0.43)	0.24 (0.43)	1.52	0.33 (0.47)	0.31 (0.46)	2.58
5. Beyond College	0.38 (0.48)	0.37 (0.48)	1.19	0.40 (0.49)	0.40 (0.49)	0.89	0.18 (0.39)	0.18 (0.38)	1.76	0.24 (0.43)	0.23 (0.42)	1.79
6. Married	0.68 (0.46)	0.68 (0.46)	-0.05	0.65 (0.48)	0.65 (0.48)	0.20	0.59 (0.49)	0.58 (0.49)	3.63	0.46 (0.50)	0.45 (0.50)	3.49
7. Non-citizen	0.02 (0.13)	0.02 (0.13)	0.00	0.01 (0.12)	0.01 (0.12)	0.00	0.27 (0.44)	0.26 (0.44)	0.45	0.17 (0.37)	0.16 (0.37)	0.86
8. Secondary Industry	0.27 (0.44)	0.27 (0.44)	0.16	0.08 (0.27)	0.08 (0.27)	0.16	0.28 (0.45)	0.27 (0.45)	0.49	0.08 (0.27)	0.08 (0.27)	0.04
9. Tertiary Industry	0.49 (0.50)	0.49 (0.50)	-0.87	0.42 (0.49)	0.42 (0.49)	-0.18	0.53 (0.50)	0.54 (0.50)	-0.34	0.46 (0.50)	0.46 (0.50)	0.07
10. Quaternary Industry	0.20 (0.40)	0.20 (0.40)	0.01	0.49 (0.50)	0.49 (0.50)	-0.38	0.16 (0.37)	0.16 (0.37)	0.26	0.45 (0.50)	0.45 (0.50)	-0.01
11. Blue Collar	0.33 (0.47)	0.33 (0.47)	0.17	0.05 (0.22)	0.05 (0.22)	0.04	0.45 (0.50)	0.46 (0.50)	-1.88	0.10 (0.30)	0.10 (0.30)	-0.02
12. Midwest	0.22 (0.41)	0.22 (0.41)	0.15	0.22 (0.41)	0.22 (0.41)	0.19	0.11 (0.31)	0.11 (0.31)	0.07	0.11 (0.31)	0.11 (0.31)	0.49
13. South	0.30 (0.46)	0.30 (0.46)	-0.12	0.30 (0.46)	0.30 (0.46)	-0.03	0.44 (0.50)	0.46 (0.50)	-3.12	0.48 (0.50)	0.49 (0.50)	-2.67
14. West	0.25 (0.43)	0.25 (0.43)	-0.05	0.24 (0.43)	0.24 (0.43)	0.35	0.31 (0.46)	0.31 (0.46)	-0.38	0.26 (0.44)	0.26 (0.44)	0.20

Table 4: Balance Statistics of Main Results 2013 - 2019

	<u>White Male</u>			<u>White Female</u>			<u>Minority Male</u>			<u>Minority Female</u>		
	B	NB	Szd.	B	NB	Szd.	B	NB	Szd.	B	NB	Szd.
1. Age	46.11 (13.84)	46.51 (13.49)	-2.88	46.13 (13.55)	46.30 (13.29)	-1.28	41.47 (12.67)	42.26 (12.81)	-6.26	42.06 (12.63)	42.51 (12.66)	-3.61
2. Number Household	2.83 (1.38)	2.74 (1.31)	6.11	2.76 (1.31)	2.69 (1.25)	5.32	3.31 (1.62)	3.18 (1.56)	8.20	3.15 (1.52)	3.00 (1.43)	9.75
3. Highschool Grad	0.27 (0.45)	0.28 (0.45)	-0.23	0.21 (0.41)	0.21 (0.41)	-0.12	0.34 (0.47)	0.34 (0.47)	0.05	0.29 (0.45)	0.29 (0.45)	-0.19
4. Some College/Grad	0.28 (0.45)	0.28 (0.45)	0.18	0.31 (0.46)	0.31 (0.46)	0.08	0.26 (0.44)	0.25 (0.43)	3.27	0.31 (0.46)	0.30 (0.46)	2.65
5. Beyond College	0.40 (0.49)	0.40 (0.49)	0.51	0.46 (0.50)	0.45 (0.50)	0.23	0.21 (0.40)	0.20 (0.40)	2.04	0.28 (0.45)	0.27 (0.44)	2.45
6. Married	0.67 (0.47)	0.67 (0.47)	-0.47	0.64 (0.48)	0.64 (0.48)	-0.83	0.57 (0.50)	0.56 (0.50)	1.11	0.44 (0.50)	0.43 (0.50)	2.13
7. Non-citizen	0.02 (0.13)	0.02 (0.12)	0.28	0.01 (0.12)	0.01 (0.12)	0.18	0.23 (0.42)	0.22 (0.42)	1.89	0.15 (0.36)	0.15 (0.35)	1.43
8. Secondary Industry	0.26 (0.44)	0.26 (0.44)	0.10	0.08 (0.26)	0.08 (0.26)	0.07	0.27 (0.45)	0.27 (0.44)	0.22	0.08 (0.27)	0.08 (0.27)	1.11
9. Tertiary Industry	0.50 (0.50)	0.50 (0.50)	-1.20	0.42 (0.49)	0.42 (0.49)	-0.25	0.53 (0.50)	0.54 (0.50)	-1.15	0.47 (0.50)	0.48 (0.50)	-0.69
10. Quaternary Industry	0.20 (0.40)	0.20 (0.40)	0.30	0.49 (0.50)	0.49 (0.50)	-0.61	0.16 (0.37)	0.16 (0.37)	1.09	0.44 (0.50)	0.44 (0.50)	-0.13
11. Blue Collar	0.32 (0.46)	0.31 (0.46)	0.49	0.05 (0.22)	0.05 (0.22)	0.13	0.44 (0.50)	0.44 (0.50)	1.55	0.11 (0.31)	0.11 (0.31)	0.97
12. Midwest	0.21 (0.41)	0.21 (0.41)	0.12	0.21 (0.41)	0.21 (0.41)	0.28	0.09 (0.29)	0.09 (0.29)	0.91	0.10 (0.30)	0.10 (0.30)	0.64
13. South	0.33 (0.47)	0.33 (0.47)	-0.17	0.33 (0.47)	0.33 (0.47)	-0.31	0.46 (0.50)	0.48 (0.50)	-2.21	0.49 (0.50)	0.51 (0.50)	-4.43
14. West	0.26 (0.44)	0.26 (0.44)	-0.05	0.26 (0.44)	0.26 (0.44)	0.25	0.32 (0.46)	0.32 (0.46)	-0.12	0.27 (0.44)	0.27 (0.44)	0.24

Table 5: Aggregate Broadband Impact on Entrepreneurial Rate and Unemployment

	2000 – 2007		2009 – 2012		2013-2019	
	Adjusted	IPW	Adjusted	IPW	Adjusted	IPW
Entrepreneurship	0.02646*** (0.00308)	0.02734*** (0.00246)	0.01286*** (0.00292)	0.01010*** (0.00251)	0.00048 (0.00296)	-0.00201 (0.00248)
Incorporated	0.01684*** (0.00194)	0.01630*** (0.00173)	0.01205*** (0.00180)	0.01106*** (0.00156)	0.00142 (0.00194)	0.00118 (0.0017)
Unincorporated	0.00962*** (0.00256)	0.01104*** (0.00318)	0.00081 (0.00248)	-0.00096 (0.00208)	-0.00094 (0.00242)	-0.00319 (0.00195)
Unemployment	-0.00625*** (0.00168)	-0.00521*** (0.00157)	-0.02185*** (0.00248)	-0.01982*** (0.00188)	-0.00410** (0.02619)	-0.00449*** (0.00135)
Obs./Treated	206,891/56,428		162,081/127,971		147,067/117,146	
Dropped	240		15		19	

Table 6: Impact of Broadband on Entrepreneurship

	2000 - 2007		2009 - 2012		2013-2019	
	Adjusted	IPW	Adjusted	IPW	Adjusted	IPW
White Male						
Entrepreneurship	0.02211*** (0.00496)	0.01877*** (0.02054)	0.00988* (0.00564)	0.00647 (0.00480)	0.00080 (0.00531)	-0.00420 (0.00434)
Incorporated	0.02356*** (0.00343)	0.02186*** (0.00318)	0.01412*** (0.00383)	0.01285*** (0.00327)	0.00148 (0.0038)	0.00244 (0.00314)
Unincorporated	-0.00145 (0.00402)	-0.00309 (0.00414)	-0.00424 (0.00463)	-0.00637* (0.00383)	-0.00068 (0.00415)	-0.00665** (0.00332)
Obs./Treated	88,636/26,387		67,113/55,365		59,635/48,260	
Dropped	0		0		0	
White Female						
Entrepreneurship	0.02345*** (0.00427)	0.02067*** (0.00426)	0.01978*** (0.00452)	0.01470*** (0.00381)	0.00228 (0.00491)	0.00035 (0.00385)
Incorporated	0.00982*** (0.00236)	0.00860*** (0.00198)	0.01184*** (0.00249)	0.00909*** (0.00206)	0.00048 (0.003)	-0.00101 (0.00264)
Unincorporated	0.01363*** (0.00376)	0.01207*** (0.00391)	0.00794** (0.00395)	0.00561* (0.00331)	0.0018 (0.00413)	0.00135 (0.00313)
Obs./Treated	79,073/22,686		60,089/49,942		52,678/43,000	
Dropped	0		0		0	
Minority Male						
Entrepreneurship	0.05363*** (0.01173)	0.06405*** (0.020554)	0.01486** (0.00611)	0.01541*** (0.00511)	-0.00042 (0.00709)	-0.00714 (0.00638)
Incorporated	0.01498** (0.00603)	0.00988*** (0.00380)	0.01225*** (0.00316)	0.01203*** (0.00272)	0.00707* (0.00385)	0.00330 (0.00363)
Unincorporated	0.03865*** (0.01042)	0.05418*** (0.02070)	0.00261 (0.00538)	0.00338 (0.00445)	-0.00749 (0.00615)	-0.01044* (0.00546)
Obs./Treated	20,085/3,649		17,683/11,262		17,577/12,946	
Dropped	568		0		5	
Minority Female						
Entrepreneurship	0.02758*** (0.0081)	0.02863*** (0.0081)	0.00502 (0.00475)	0.00337 (0.00397)	0.00302 (0.00584)	0.00404 (0.00500)
Incorporated	0.00825** (0.00379)	0.00780** (0.00389)	0.00554*** (0.00195)	0.00480*** (0.00168)	0.00041 (0.00308)	0.00079 (0.00288)
Unincorporated	0.02196*** (0.00687)	0.02082*** (0.00722)	-0.00052 (0.00435)	-0.00146 (0.00364)	0.00261 (0.00511)	0.00325 (0.00419)
Obs./Treated	19,097/3,706		17,196/11,402		17,177/12,940	
Dropped	719		0		0	

Table 7: Impact of Broadband on Unemployment

	2000 - 2007		2009 - 2012		2013-2019	
	Adjusted	IPW	Adjusted	IPW	Adjusted	IPW
White Male						
Unemployment	-0.00256 (0.00218)	-0.00281 (0.00192)	-0.02366*** (0.00401)	-0.02024*** (0.00316)	-0.00531* (0.00281)	-0.00566*** (0.00204)
Obs./Treated	88,636/26,387		67,113/55,365		59,635/48,260	
Dropped	0		0		0	
White Female						
Unemployment	-0.00085 (0.00247)	0.000270 (0.00273)	-0.01108*** (0.00383)	-0.00863*** (0.00288)	-0.00106 (0.00296)	-0.00170 (0.00210)
Obs./Treated	79,073/22,686		60,089/49,942		52,678/43,000	
Dropped	0		0		0	
Minority Male						
Unemployment	-0.02593*** (0.00808)	-0.02069*** (0.00651)	-0.03289*** (0.00656)	-0.04044*** (0.00570)	-0.00589 (0.00539)	-0.00658 (0.00433)
Obs./Treated	20,085/3,649		17,683/11,262		17,577/12,946	
Dropped	568		0		5	
Minority Female						
Unemployment	-0.01932** (0.00797)	-0.01997*** (0.00742)	-0.03344*** (0.00681)	-0.03325*** (0.00565)	-0.00797 (0.00607)	-0.00705 (0.00484)
Obs./Treated	19,097/3,706		17,196/11,402		17,177/12,940	
Dropped	719		0		0	

Table 8: Impact of Broadband on Weekly Earnings in 2015 US Dollars

	2000 - 2007		2009 - 2012		2013 - 2019	
	Adjusted	IPW	Adjusted	IPW	Adjusted	IPW
Everyone	155.77*** (11.34)	144.16*** (11.06)	139.55*** (11.51)	138.87*** (12.74)	52.66*** (13.13)	56.70*** (13.37)
Obs.	43,807/12,020		33,939/26,952		31,616/27,508	
Dropped	333		39		18	
White Males	192.38*** (19.19)	153.88*** (17.14)	148.95*** (22.51)	144.43*** (25.49)	69.56*** (24.59)	65.46*** (23.95)
Obs.	17,842/5,440		13,366/11,201		12,434/11,061	
Dropped	0		15		27	
White Females	107.26*** (15.87)	78.78*** (14.02)	115.99*** (17.71)	116.73*** (16.53)	18.95 (21.42)	28.32 (19.84)
Obs.	17,266/4,949		13,111/10,924		11,578/10,355	
Dropped	0		9		11	
Minority Males	106.82*** (21.35)	172.16*** (41.52)	168.62*** (21.88)	152.78*** (19.37)	87.52*** (15.41)	51.88** (26.66)
Obs.	4,305/790		3,724/2,348		3,783/2,996	
Dropped	1,570		105		1,493	
Minority Females	115.42*** (12.82)	188.18*** (33.43)	115.29*** (19.79)	94.62*** (17.68)	89.66*** (16.94)	98.38*** (22.05)
Obs.	4,394/841		3,738/2,479		3,821/3,096	
Dropped	2,486		68		1,046	

Table 9: Impact of Broadband on Entrepreneurial Income (Annual, Single Adult Family Only) in 2015 US Dollars

	2000 - 2007		2009 - 2012		2013 - 2019	
	Adjusted	IPW	Adjusted	IPW	Adjusted	IPW
Entrepreneur	34,090*** (1,682)	18,090*** (6,722)	14,345*** (975)	14,980*** (1,932)	6,188.8*** (847)	7,453.67*** (1,787)
Obs.	411/125		2,134/1,476		2,777/2,016	
Dropped	403		1,619		2,102	
Incorporated	n/a ¹	23,660 (20,869)	20,489*** (1,465)	24,050** (10,234)	5,561*** (942)	2,072 (3,671)
Obs.	98/35		590/474		829/658	
Dropped	n/a		526		768	
Unincorporated	23,954*** (1,379)	10,447*** (3,551)	9,436.1*** (937)	11,763*** (2,002)	8,125.5*** (809)	8,084*** (1,942)
Obs.	304/82		1,544/1,002		1,948/1,358	
Dropped	298		1,248		1,542	

¹Nearest Neighbor Matching resulted in less than two valid matches.

Table 10: Impact of Broadband on More Than One Job

	2000 - 2007		2009 - 2012		2013-2019	
	Adjusted	IPW	Adjusted	IPW	Adjusted	IPW
Everyone						
More Than 1 Job	0.00515** (0.00238)	0.00516** (0.00211)	0.01081*** (0.00237)	0.01039*** (0.00203)	0.00715*** (0.00222)	0.00756*** (0.00174)
Obs./Treated	199,658/54,887		151,114/120,625		141,347/113,146	
Dropped	220		14		25	
White Male						
More Than 1 Job	0.00264 (0.00343)	0.00303 (0.00303)	0.00761* (0.00396)	0.00585 (0.00368)	0.00981*** (0.00348)	0.00986*** (0.00263)
Obs./Treated	86,123/25,731		63,047/52,441		57,626/46,831	
Dropped	0		0		0	
White Female						
More Than 1 Job	0.00267 (0.0038)	0.00271 (0.00332)	0.01131*** (0.00431)	0.01162*** (0.00357)	0.00732 (0.00420)	0.00301 (0.00328)
Obs./Treated	76,695/22,091		56,946/47,509		50,980/41,744	
Dropped	0		0		0	
Minority Male						
More Than 1 Job	0.00927 (0.00822)	0.01583* (0.00926)	0.00989** (0.00450)	0.01453*** (0.00383)	0.01273*** (0.00489)	0.01037*** (0.00391)
Obs./Treated	18,976/3,510		15,755/10,268		16,625/12,334	
Dropped	538		6		5	
Minority Female						
More Than 1 Job	0.01544** (0.00756)	0.01123 (0.00720)	0.02124*** (0.00471)	0.01518*** (0.00387)	0.01291** (0.00537)	0.01113*** (0.00423)
Obs./Treated	17,864/3,555		15,366/10,407		16,116/12,237	
Dropped	698		0		0	

Figure 1: Broadband Adoption by Gender and White/Minority

*Broadband access includes: DSL/Cable/Fiber-optic, Satellite, Mobile

Figure 2: Self-Employment by Gender and White/Minority

Black curve: all groups. Orange curve: White Male. Grey Curve: White Female. Yellow curve: Minority Male. Blue curve: Minority Female.

Figure 3: Entrepreneurial Type by Periods

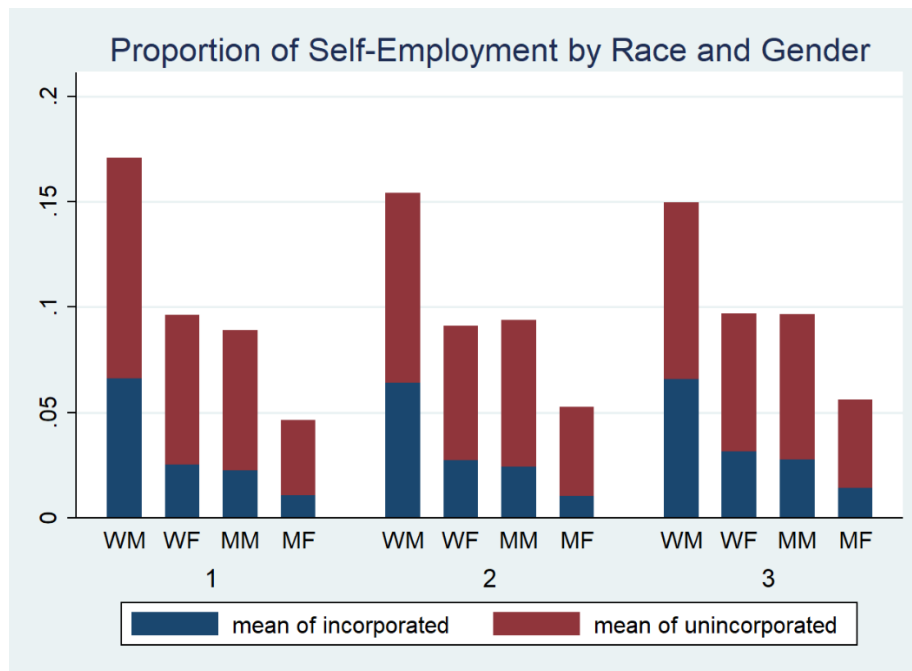
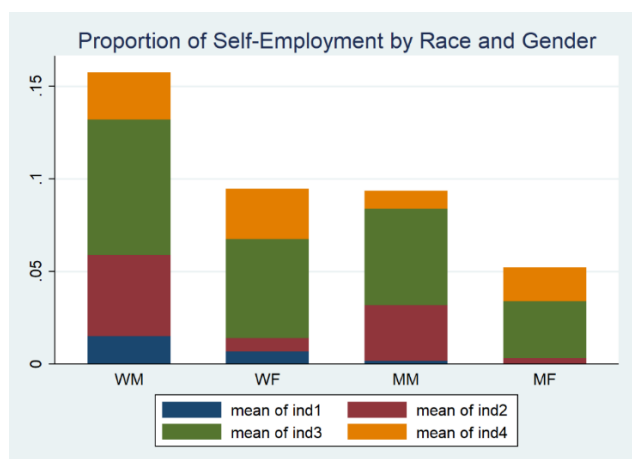


Figure 4: Entrepreneurial Industry by Gender/Race Groups



Primary Industry (ind1): Agriculture and Mining. Secondary (ind2): Construction and Manufacturing. Tertiary (ind3): Wholesale/Retail, Transportation/Utilities, profession/Business Services, Leisure/Hospitality, Other Services and Public Admin. Quaternary (ind4): Information, Financial and Education/Health Services. Occupation is categorized into white collar (occ1) and blue collar (occ2).

Figure 5: Incorporated and Unincorporated Entrepreneurship by Gender and White/Minority

Black curve: all groups. Orange curve: White Male. Grey Curve: White Female. Yellow curve: Minority Male.
Blue curve: Minority Female.

Figure 6: Proportion of Unemployment by Race and Gender

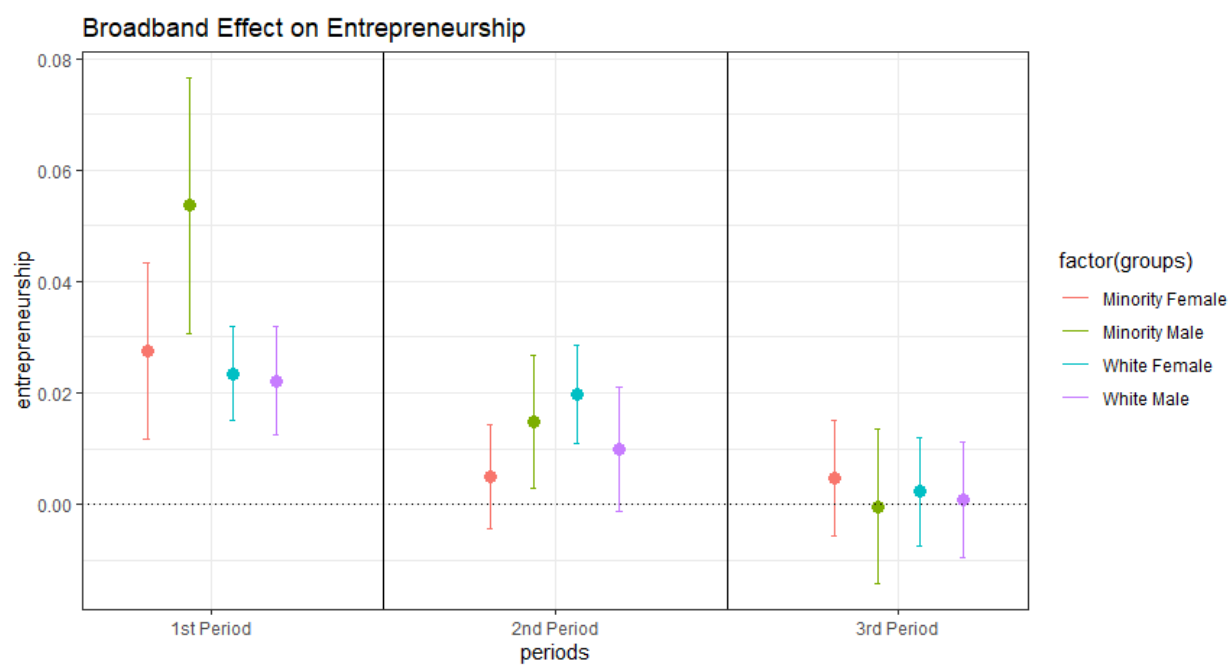
Figure 7: Proportion of More Than One Job by Race and Gender

Black curve: all groups. Orange curve: White Male. Grey Curve: White Female. Yellow curve: Minority Male. Blue curve: Minority Female.

Figure 8: Earnings and Income by Race and Gender:

Top Graph: Black curve: all groups. Orange curve: White Male. Grey Curve: White Female. Yellow curve: Minority Male. Blue curve: Minority Female. Bottom Graph: Blue curve: Single adult family income for all (incorporated and unincorporated). Orange curve: Single adult family income for incorporated entrepreneurs. Grey curve: Single adult family income for unincorporated entrepreneurs.

Figure 9: Significance of Differences in Broadband Entrepreneurship by Gender and Race



Nearest-neighbor matching estimates of broadband impact on Entrepreneurship and Unemployment, with 95% A.I. Robust standard errors.

Figure 10: Significance of Differences in Broadband Effects of Types of Entrepreneurships

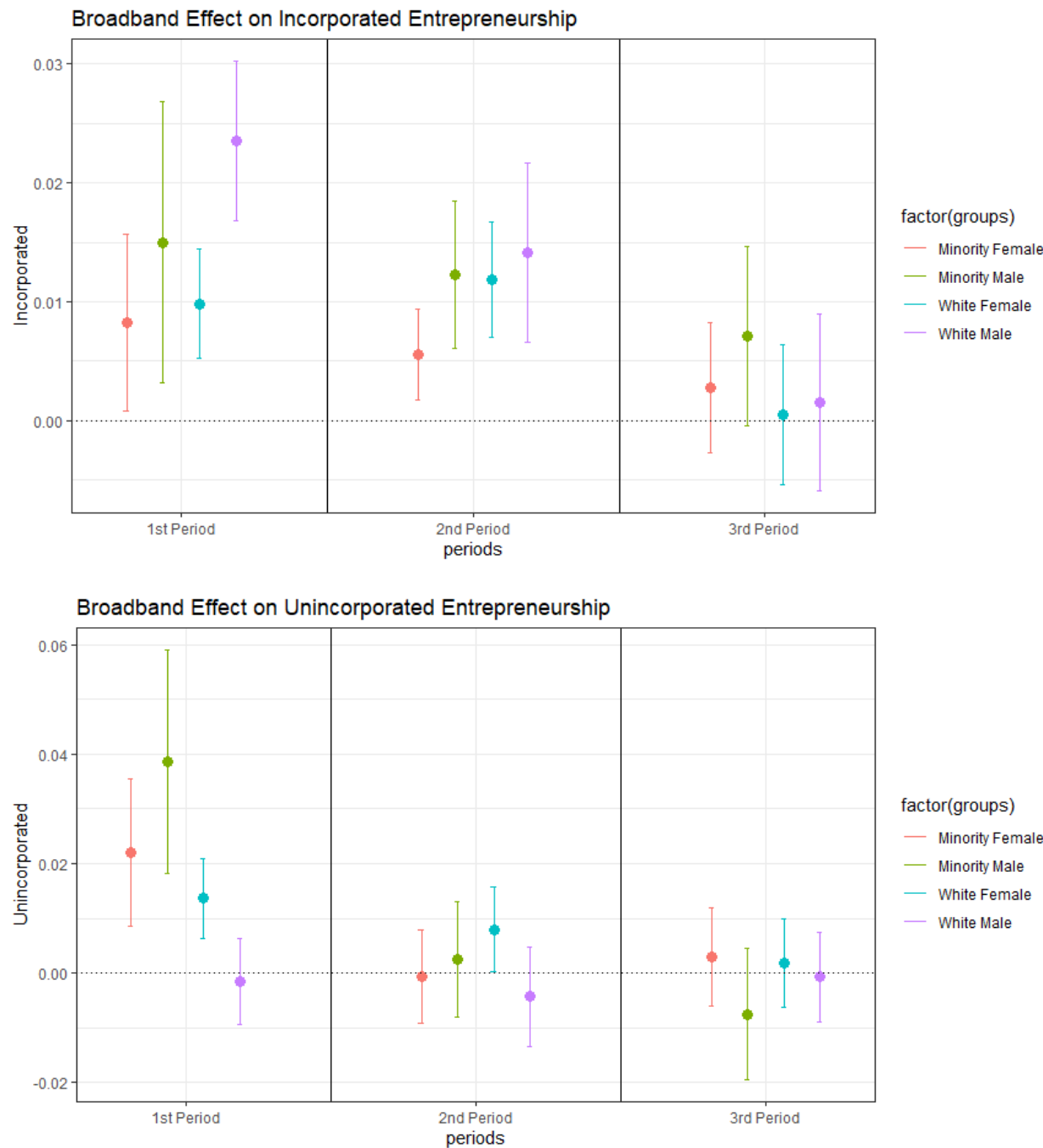
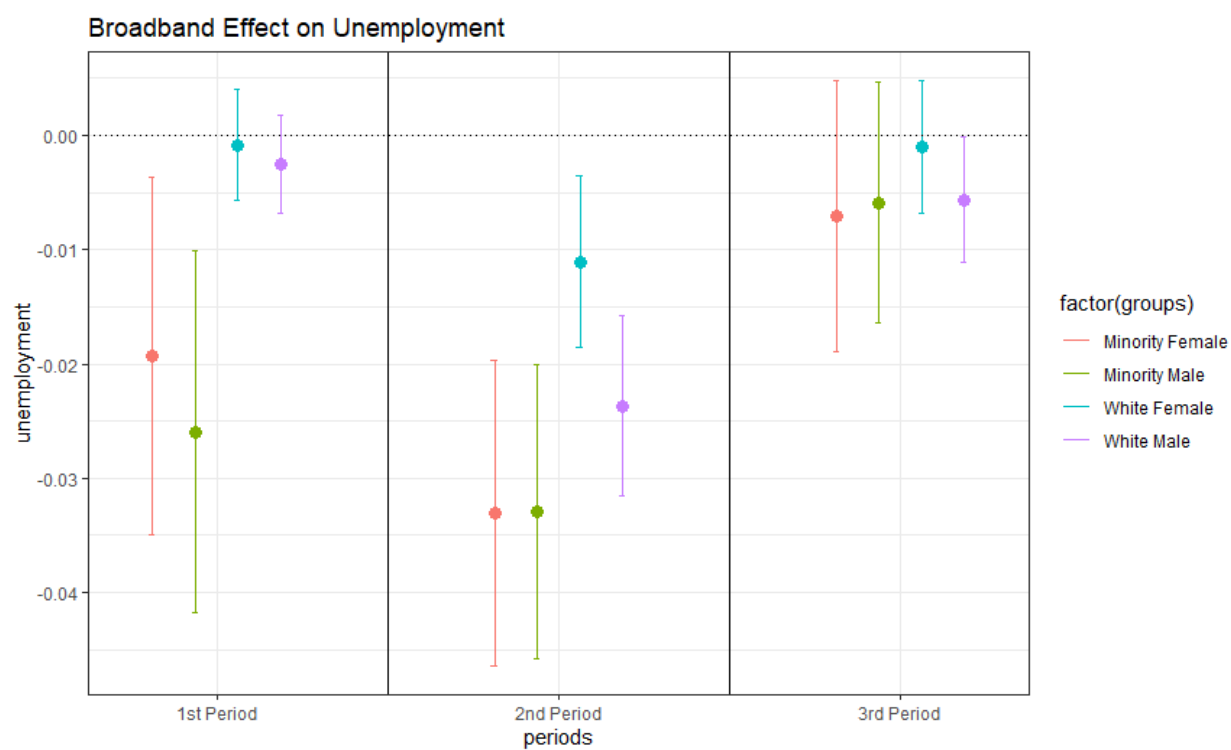


Figure 11: Significance of Differences in Unemployment Effects by Gender and Race



Nearest-neighbor matching estimates of broadband impact on Entrepreneurship and Unemployment, with 95% A.I. Robust standard errors.

Figure 12: Significance of Differences in Broadband Earnings Effects by Gender and Race

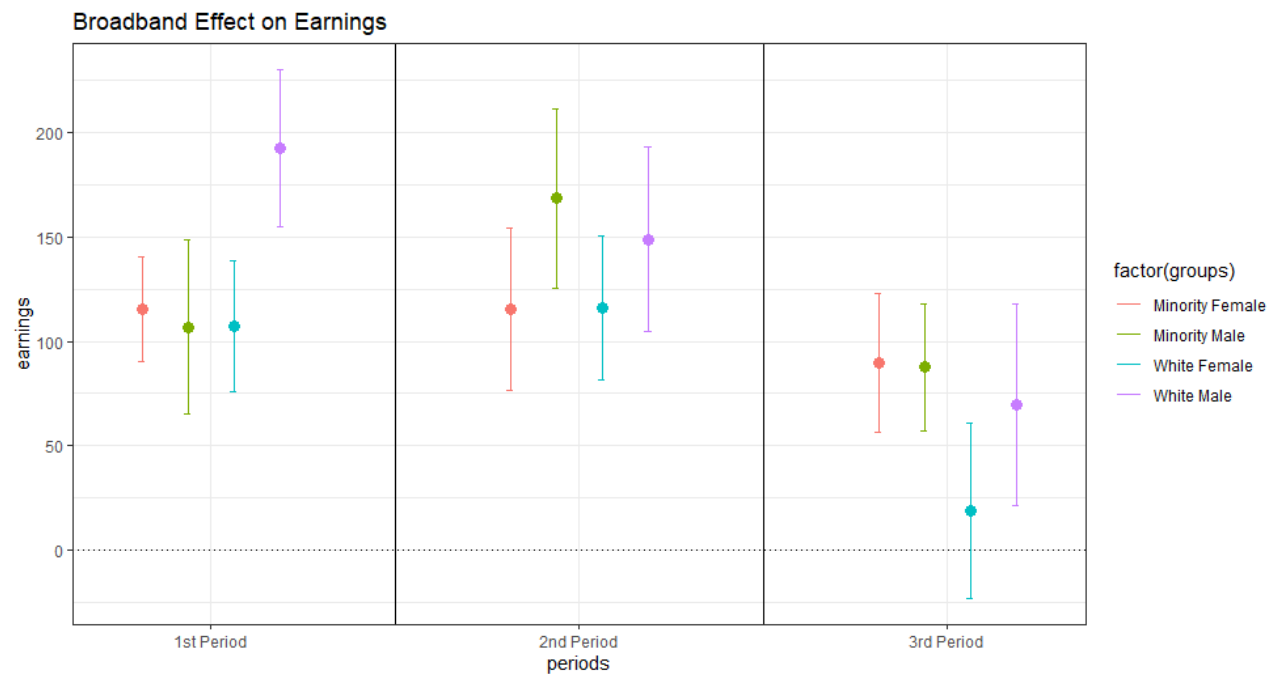
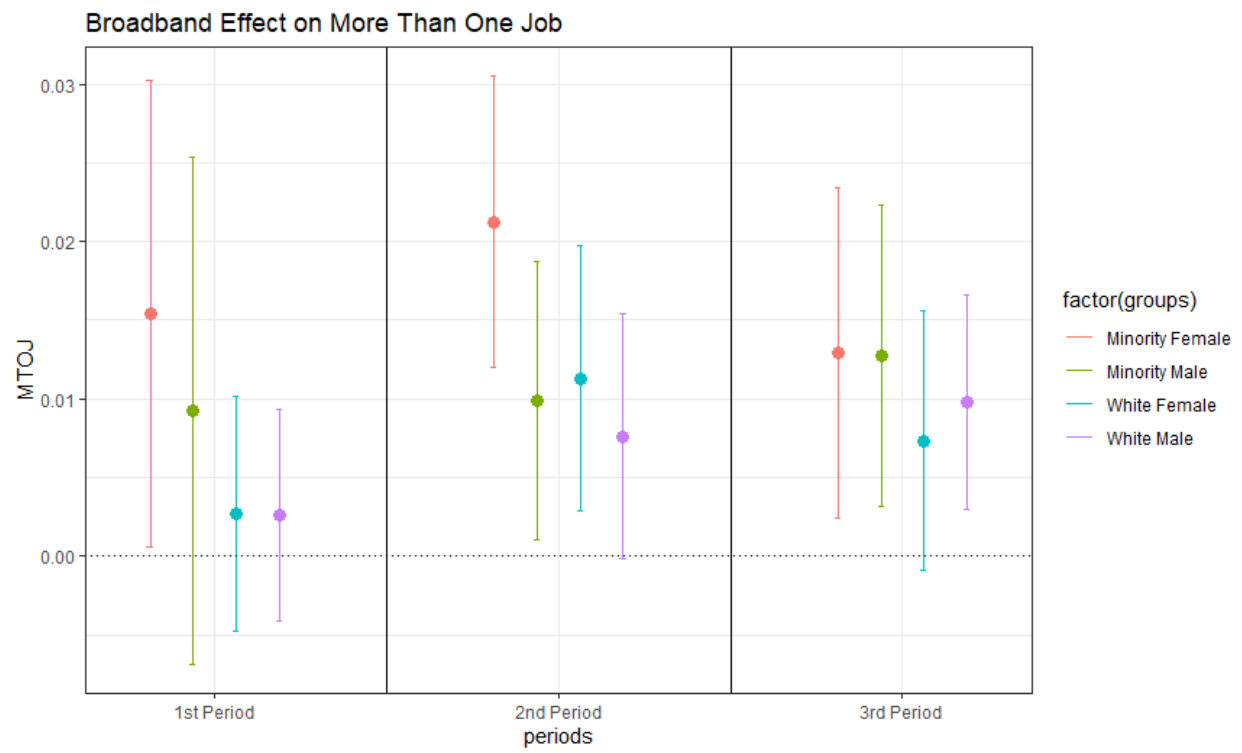


Figure 13: Significance of Differences in Broadband Effects on Taking More Than One Job by Gender and Race



Appendix Figure 1: Love Plots by Gender/Race and Periods

White Male: 2000 – 2007, 2009 – 2012, 2013 - 2019

White Female: 2000 – 2007, 2009 – 2012, 2013 - 2019

Minority Male: 2000 – 2007, 2009 – 2012, 2013 - 2019

Minority Female: 2000 – 2007, 2009 – 2012, 2013 - 2019

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