In the 21st century, more and more activities are either replaced or augmented by digital technology and Internet connectivity. During the pandemic as face-to-face interactions have been curtailed, we have seen an acceleration of e-commerce. Figure 1 shows the year-over-year growth of total and e-commerce retail sales. E-commerce sales, which already had a higher growth rate than did total sales prior to March 2020, skyrocketed during the pandemic.

E-commerce is just one example of why infrastructure for broadband and computer access is increasingly important in the digital age. One lesson we learn from the pandemic is that having broadband and computer access might become even more important in the fields of education, public health and medical care. For instance, Yu (2021) finds that, after controlling for various demographic, age, socioeconomic, education, and health factors, a county with a higher percentage of computer and broadband access had a significantly lower cumulative COVID-19 mortality rate and confirmed case rate. One possible explanation is that people with computer and broadband access can more easily access COVID-19 information, make appointments with doctors or use telehealth services, order groceries online for delivery, and work from home. Especially in light of the pandemic, it should not be surprising that we hypothesize that computer and broadband access is associated with local economic prosperity, a relationship we address later in this report.

Among 37 OECD countries, the fixed broadband subscription rate in the U.S. (36%, or 36 subscriptions per 100 people) ranked 18, lower than Switzerland (47.6%), South Korea (42.8%), and Canada (41.2%) (Figure 2). This is one of the reasons that the Biden Administration’s initial proposal called for spending $100 billion to expand U.S. broadband access as part of the infrastructure plan and why the May Revision to Governor Newsom’s budget proposes investing $7 billion in broadband infrastructure in California. The White House website describing the infrastructure plan expresses the view that “[b]roadband internet is the new electricity,” conveying the position that internet access has become an essential utility.2

Based on the American Community Survey in 2019, 82.7% of American households have a broadband Internet subscription and 90.3% of households have a computer.4 Figure 3 and Figure 4 show broadband penetration (the fraction of residents with broadband connectivity) and computer access rates by county. We can see a disparity of digital infrastructure across the country. There is higher usage and availability of computers and broadband in coastal regions but lower connectivity in the South and in some (though not all) more rural areas. Figure 5 displays the correlation between broadband subscription and computer ownership. There is a strong and positive association – counties with higher computer ownership rates also tend to be counties with higher broadband penetration rates. For example, in Los Angeles County, 92% of households have a computer and 84.3% of households have a broadband subscription.

3. The subscription includes both fixed and mobile broadband.
4. The definition of a computer includes desktops, laptops, smartphones, and tablets. Note that the American Community Survey statistic essentially divides the number of subscriptions by the number of households, whereas the OECD statistics divide by the number of people.
Figure 2  Fixed Broadband Subscription Rate (% of People with a Subscription)


Figure 3  Fraction of Households with A Broadband Internet Subscription (%)

Source: Blue colors indicate higher percentages. The subscription includes both fixed and mobile broadband. 
Source: 2019 Five-year American Community Survey
Figure 5  Correlation Between Broadband Subscription and Computer Ownership

Source: 2019 Five-year American Community Survey

Digital Infrastructure and the Local Economy

We now turn to assessing the evidence for whether digital infrastructure penetration, e.g. broadband subscriptions and computer ownership, helps the local economy. The answer seems to be yes. Figure 6 presents the correlation between the percent of households with a broadband subscription in 2019 and the unemployment rate in March 2021 across counties. We can see a slightly negative correlation (the simple correlation is -0.22), suggesting that a county with a higher broadband penetration rate tends to have a lower unemployment rate.\(^5\)

Let’s take a deeper look at how broadband is associated with the unemployment rate. We test various specifications of linear regression models where the dependent variable is the county’s unemployment rate in March 2021. These specifications are shown in the following summary table and the detailed regression results are presented in the appendices. Equation 1 is a univariate regression where the only explanatory variable is the broadband subscription rate.

\(^5\) The negative correlations between a broadband subscription in 2019 and unemployment rates in months of 2019 and 2020 are stronger than those in months in 2021.
In Equations 2 to 7, we ran several multivariate regressions by including additional reasonable predictors (listed in the table) of county unemployment rates to explain the variation in the cross section. Across all specifications, the broadband variable is statistically significant and inversely related to the unemployment rate. In other words, after controlling for these other variables, a county with a higher broadband subscription rate has a lower unemployment rate.

Focusing specifically on the results of Equation 6, the broadband subscription rate is statistically significant at the 0.1% level. Its coefficient is -0.016, meaning that a 10 percentage point increase in a county’s broadband subscription rate is associated with a 0.16 percentage point decline in the unemployment rate. Here we control for the unemployment rate in February 2020, before the pandemic. This variable (urate2002) could account for unique characteristics related to job markets of the county that cannot be directly observed in our regressions. We also control for the unemployment rate in April 2020 (urate2004), which was the worst month of the COVID-19 pandemic for labor markets, at least as measured by the unemployment rate. The variable (urate2004) can address the differentiated impact of the pandemic on

<table>
<thead>
<tr>
<th>Eq.</th>
<th>Main Explanatory Variable</th>
<th>Other Explanatory Variables</th>
<th>Adj. R-Squared</th>
<th>Appendix Number</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Broadband***</td>
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<td>3</td>
<td>Broadband***</td>
<td>CHCI, Median income, Urate in Feb. 2020, Urate in Apr. 2020</td>
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<td>4</td>
<td>Broadband***</td>
<td>CHCI, Median income, Urate in Feb. 2020, Urate in Apr. 2020</td>
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<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Broadband***</td>
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<td>2</td>
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<tr>
<td>6</td>
<td>Broadband***</td>
<td>CHCI, Median income, Urate in Feb. 2020, Urate in Apr. 2020, Population, Population density, COVID case rate, COVID death rate</td>
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<td>7</td>
<td>Broadband***</td>
<td>CHCI, Median income, Urate in Feb. 2020, Urate in Apr. 2020, Population, Population density, COVID case rate, COVID death rate, State fixed effect</td>
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<td>8</td>
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<td>9</td>
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<td>0.532</td>
<td>4</td>
</tr>
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</table>

Note: *** denotes statistical significance at the 0.1% level, ** at the 1% level, * at the 5% level.
each county. Both variables are highly significant and positively correlated with the latest unemployment rate. We also include measures of human capital (chci; the City Human Capital Index, an index of educational attainment developed by the UCLA Anderson Forecast and based on American Community Survey data) and median household income (mincome) as unemployment rates are known to vary by education and income. The variables for county population in 2019 (population19) and population density (pdensity) are highly significant and positive, suggesting that larger metros and metro cores are facing a slower recovery. One possible reason is that some urban residents moved (either temporarily or permanently) to suburban or rural counties to get away from the pandemic since urban amenities were curtailed by mitigation policies and since remote work is available.

In Equations 8 and 9, we switch the digital infrastructure variable to computer ownership from broadband. We have a clear significant and negative simple correlation between computers and the unemployment rate in Equation 8, but in the multivariate regression setting, the computer variable is not significant anymore. That said, in terms of digital infrastructure, the results suggest that broadband access is more important than computer access. One explanation is that without broadband connectivity, a computer is less productive to foster business and the economy. We will discuss this in the next section.

Broadband, Online Microbusinesses, and the Local Economy

Now the question is, why is higher broadband access positively associated with local economic activity, e.g. a lower unemployment rate? One possible channel is that broadband access enables more residents to engage in virtual business, e-commerce, and non-profit activity. In particular, in the pandemic, having broadband access and an online business presence was crucial when brick-and-mortar shopping was curtailed.

Here we analyze data from GoDaddy, one of the leading providers of Internet domain names with a market share of about 40% in the U.S. and over 11 million customers who have over 40 million online microbusinesses in the U.S. The data from GoDaddy are based on information about all individuals who have purchased a domain name from GoDaddy. We use data that are not restricted by how that domain name is used (e.g. for online retail, for informational purposes, for email) or whether the domain name is linked to a publicly accessible website at the time the data were pulled from the database. This is because we do not want to impose subjective judgement on how different individuals use domains for business purposes and because domains may not initially be linked to a public website at the time they are first recorded in the data. Given the size of their business, GoDaddy’s data provide a comprehensive picture

6. For details, see: https://www.anderson.ucla.edu/centers/ucla-anderson-forecast/projects-and-partnerships/city-human-capital-index
of online microbusinesses. Figure 7 shows the density of online microbusinesses, which is calculated as the number of active Internet domain names purchased from GoDaddy divided by the county’s population. The reason we call them microbusinesses is because GoDaddy’s business customers are mostly small businesses or non-profits (55% are sole proprietorships and an additional 37% are small businesses with one to ten employees).\(^7\)

Figure 8 reveals a clearly positive association between broadband access and the density of GoDaddy’s online microbusinesses. Equation 10 in Appendix 4 also presents the statistically significant relationship between digital infrastructure and online microbusinesses.

Now let’s see if there is a correlation between GoDaddy’s online microbusinesses and the local economy. In Equation 11 in Appendix 5, we run a panel regression using data from June 2018 until March 2021 of county unemployment rates on a set of variables that control for specific time and state characteristics, the density of microbusinesses, and COVID-19 new cases and deaths per capita. We find that the

\(^7\) This is based on a survey conducted by GoDaddy in July 2020 that was sent to a randomly selected subset of its customers. The number of respondents is 2,330.
density of microbusinesses is significantly negatively correlated with the unemployment rate. In other words, a county with a higher concentration of online microbusinesses tends to also have a lower unemployment rate.

In Equation 12 in Appendix 6, we change the dependent variable to the employment to population ratio, which is another measure of labor market strength. We again see evidence that there is a significantly positive association between online microbusiness density and the employment rate. Note that these two equations cannot necessarily prove that there is a causal relationship from online microbusinesses to local economic activity. In Equation 13, we try to investigate this possibility with a dynamic relationship. The dependent variable is the change in a county’s employment between two time periods and the explanatory variable of interest is the change in the number of microbusinesses. In order to control for the variation in county size, we add county population and replace COVID-19 new cases and deaths per capita with the simple count of new cases and deaths in a county. We also control for trends and persistence in employment by including a lag of the employment change. We find a significant and positive relationship between changes in the number of online microbusinesses and changes in local employment. We view this as stronger, though not irrefutable, evidence that online microbusinesses contribute to employment growth and strengthen local labor markets.

An Index for Online Microbusinesses

We want to take this link between online microbusinesses, broadband, and the local economy a step further with a few considerations. First, the broadband penetration rate does not fully explain everything about online microbusinesses. Broadband access is necessary, but not sufficient. For example, entrepreneurship may also require access to capital (such as loans or grants) and certain types of human capital (such as business management and computer skills) that increase the entrepreneur’s ability to use computers and broadband connectivity to create and support their online business activities. Second, the number of microbusinesses per capita is just one aspect of online microbusinesses and only captures the extensive margin – how many there are – not the intensive margin – how active or successful they are. It is reasonable to think that the intensive margin matters for the link between online microbusinesses and local economies. In order to capture all the aspects of microbusinesses, we create an index of online microbusinesses.

Our index incorporates variables that capture various facets of online microbusinesses. These variables come from a subset of GoDaddy’s data (April 2020 through March 2021). The data contain characteristics about GoDaddy’s customers (individuals who buy domain names and business website services from GoDaddy) and their customer’s websites. Our index aims to capture three facets of online microbusinesses: receptivity, reception, and activity. (1) Receptivity is the physical and intellectual infrastructure needed to access and use the Internet. (2) Reception (which captures the extensive margin) is the number of GoDaddy customers and microbusinesses as a percentage of the population of each locale. (3) Activity (which captures the intensive margin) is the frequency and intensity with which those microbusiness websites are updated by the microbusiness owners and used by their customers. To capture receptivity, we use data from the most recent American Community Survey (2019 five-year estimates). The variables include the City Human Capital Index, the fraction of residents with broadband internet subscriptions, and the fraction of residents with computer access. For reception and activity, we map the variables from GoDaddy into these categories. For reception, we use measures of the number of GoDaddy customers and microbusinesses. To capture activity, we use variables that reflect the intensity of website use by the business owner (such as measures of website complexity and update frequency) and the business’s customers (such as measures of website traffic). We create a composite index (‘even-weight index’) which is comprised of all three components and we also create three sub-indices, one each of receptivity, reception, and activity.8

8. See Appendix A for details and a discussion of the time series patterns of the index. A complete discussion of the index is in a forthcoming special report about online microbusinesses from the UCLA Anderson Forecast.
DIGITAL INFRASTRUCTURE, THE ECONOMY AND ONLINE MICROBUSINESSES: EVIDENCE FROM GODADDY’S MICROBUSINESS DATA

These components are related, but not perfectly so. Figure 9 shows how the sub-indices of receptivity (which includes broadband access) and reception by state correlate and rank, where higher values of the receptivity sub-index indicate higher digital infrastructure and human capital, and higher values of the reception sub-index indicate more online businesses. Consistent with the positive correlation between broadband and online microbusiness density in Figure 8, we find a positive correlation (the red line) between receptivity and reception. The figure shows that D.C., a dense urban city and the national capital, has the highest index values while Mississippi and West Virginia have the lowest. States that are above the red line (average regression line), such as Florida, California, New York, Nevada, and Arizona, have better reception than the national average given their receptivity. On the other hand, those below the red line, such as Alaska, Minnesota, and Wisconsin, have relatively weaker reception given their receptivity.

The question we want to ask here is whether the index captures variation in labor market outcomes, such as the unemployment rate, that is not explained by microbusiness density alone. We can get a sense that microbusiness density...
and our index capture different information by comparing Figure 10, which shows the variation in the composite index across counties in March 2021, and Figure 7, which shows microbusiness density. This comparison indicates that our index captures information about online microbusinesses that is not fully reflected in the number of microbusinesses per capita. In both measures, the coasts tend to both have higher values of the index and higher microbusiness density, but the Midwest and mountain states have higher index values despite having relatively lower reception (number of microbusinesses per capita).

We repeat the analysis in the prior section (Equations 11, 12, and 13), but add our composite index as an explanatory variable (evenWgtIndex) and limit the sample period to April 2020 – March 2021, the time period for which we can calculate the index. If our index is useful for explaining the variation in local labor markets above and beyond what we can learn from microbusiness density, we would expect to see that the coefficient on the index is statistically significant. We find that this is the case for the analogs of Equations 11 and 12, but is not the case for the analog of Equation 13 (see the table below and the full results in Appendix 8 showing Equations 11B – 13B). In the cases of Equations 11B and 12B, the coefficient on our index is statistically significant and of the predicted sign: counties with a higher index value tend to have lower unemployment rates and higher employment to population ratios even after controlling for microbusiness density. The coefficients on our index variable are also larger in magnitude than are those on the density variable, and the microbusiness density coefficients change sign relative to Equations 11 and 12. In the case of Equation 13B, we do not find that changes in the index (evenWgtIndex_D1) help explain changes in employment above and beyond the microbusiness density variable. One possible explanation is that our index better explains cross-sectional patterns than time series patterns. Still, these results generally support the idea that the microbusiness density variable (part of the reception component of the composite index) misses information about online microbusinesses and highlights the importance of including other facets of online microbusinesses in our index, such as the activity component.

### Conclusions

Broadband is necessary and important infrastructure in the digital era of the 21st century. It allows people to connect, learn, teach, sell products to a larger market, and do business. The report provides three findings: (1) Counties with higher broadband access have a lower unemployment rate, (2) Counties with more broadband access have more online microbusinesses and that the presence of these businesses correlates with better labor market outcomes, and (3) the number or density of microbusinesses alone is not sufficient to describe all aspects of online microbusinesses, so we develop an index with three components, receptivity, reception, and activity, that illuminates real-time dynamics for this understudied type of small business.

<table>
<thead>
<tr>
<th>Eq.</th>
<th>Dependent Variable</th>
<th>Main Explanatory Variable</th>
<th>Other Explanatory Variables</th>
<th>Adj. R-Squared</th>
<th>Appendix Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>11B</td>
<td>Unemployment rate</td>
<td>Even-weight index ***</td>
<td>Microbusiness density, COVID case rate, COVID death rate, State fixed effects, Time fixed effects</td>
<td>0.605</td>
<td>8</td>
</tr>
<tr>
<td>12B</td>
<td>Employment to population</td>
<td>Even-weight index ***</td>
<td>Microbusiness density, COVID case rate, COVID death rate, State fixed effects, Time fixed effects</td>
<td>0.482</td>
<td>8</td>
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<tr>
<td>13B</td>
<td>Change in employment</td>
<td>Change in even-weight index</td>
<td>Lag(change in employment), Change in the number of microbusinesses, COVID cases, COVID deaths, State fixed effects, Time fixed effects</td>
<td>0.242</td>
<td>8</td>
</tr>
</tbody>
</table>
Appendix 1

**Equation 1. Dependent Var: Unemployment Rate in March 2021**

<table>
<thead>
<tr>
<th>coefficient</th>
<th>estimate</th>
<th>std error</th>
<th>t statistic</th>
<th>p value</th>
</tr>
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<tbody>
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Observations: 2865  
Adj. R2: 0.05

**Equation 2. Dependent Var: Unemployment Rate in March 2021**

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<th>coefficient</th>
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<th>t statistic</th>
<th>p value</th>
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<tbody>
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<td>0.005</td>
<td>-3.394</td>
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<tr>
<td>mincome</td>
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<td>0.022</td>
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Observations: 2865  
Adj. R2: 0.058

**Equation 3. Dependent Var: Unemployment Rate in March 2021**

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<th>std error</th>
<th>t statistic</th>
<th>p value</th>
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Observations: 2865  
Adj. R2: 0.446

**Equation 4. Dependent Var: Unemployment Rate in March 2021**

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<th>coefficient</th>
<th>estimate</th>
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<th>t statistic</th>
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Observations: 2865  
Adj. R2: 0.474
Appendix 2

### Equation 5. Dependent Var: Unemployment Rate in March 2021

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<td>0.021</td>
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<td>pdensity</td>
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Observations: 2864
Adj. R2: 0.521

### Equation 6. Dependent Var: Unemployment Rate in March 2021

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<th>t statistic</th>
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Observations: 2864
Adj. R2: 0.533
Appendix 3

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Observations: 2864  Adj. R2: 0.826
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Observations: 2865

Adj. R²: 0.05

### Equation 9. Dependent Var: Unemployment Rate in March 2021

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Observations: 2864

Adj. R²: 0.532

### Equation 10. Dependent Var: Density of GoDaddy’s Online Microbusiness

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Observations: 2866

Adj. R²: 0.025
## Appendix 5

### Equation 11. Dependent Var: Unemployment Rate

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**Observations: 67,622**  
**Adj. R2: 0.639**
## Appendix 6

### Equation 12. Dependent Var: Employment to Population Ratio

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**Observations:** 67,597  
**Adj. R²:** 0.37
### Equation 13. Dependent Var: Employment Difference Over Two Periods

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**Observations:** 67,592  
**Adj. R2:** 0.092
### Appendix 8

**Equation 11B. Dependent Var: Unemployment Rate**

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*(date and state controls omitted from the table)*

Observations: 31760  Adj. R2: 0.605

**Equation 12B. Dependent Var: Employment to Population Ratio**

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*(date and state controls omitted from the table)*

Observations: 31748  Adj. R2: 0.482

**Equation 13B. Dependent Var: Employment Difference Over Two Periods**

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*(date and state controls omitted from the table)*

Observations: 28993  Adj. R2: 0.242
Appendix A

To calculate the main or composite index, we first normalize the GoDaddy variables, to create a common scale, and then take the average over these (normalized) variables. In addition to the composite index, we create sub-indices for three facets of online microbusinesses (reception, receptivity, and activity) using the variables that pertain to each category. We then re-scale all indices (the composite and the three sub-indices separately) and center them to average 100 in April 2020.

The activity dimension plays a major role in the variation of the index over time. This can be seen in Figure 11, which shows the composite index for the U.S. as a whole along with the three sub-indices for receptivity, reception, and activity. The composite index rises in May 2020, followed by a slight dip in June, then a steady rise through September. The index falls in October and November, but since then has generally risen. This pattern largely fits with the economic stopping and starting since April 2020 due to the pandemic, recession, and recovery. Initially, businesses may have invested in their online presence, leading to a spike in May. Businesses started to open up in the summer, but some areas reinstated restrictions as coronavirus cases rose in the fall, which could explain the index’s decline from September through November. The holiday and shopping season, with more consumers looking to make their holiday purchases online, likely contributed to the rise in the index since November. When we collect multi-year data, we will be able to detect whether there is a seasonal pattern in the activity index.

The figure also shows that reception (which captures the extensive margin – the growth rate and number of how many online microbusinesses are operating) smoothly rose in the summer, fell in the fall/early winter and then rose, giving an indication of when businesses decided to take their operations online. Receptivity is flat through the sample period, which is by construction since receptivity is based on variables that are only updated at an annual frequency. The variation in the activity index (which captures the intensive margin – how intensively and frequently business owners and their customers use the business’s website) is what seems to be driving the main patterns we see in the composite index, suggesting that much of the variation in our composite index, at least over this historically unusual time period, is driven by the intensive margin of online microbusiness owners’ and their customers’ use of the business’s websites.

Figure 11. Microbusiness Index Time Series (U.S.) – Even-Weight Index

Sources: GoDaddy and UCLA Anderson Forecast

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9. We also employ more complex methods to create an index that is a weighted average, rather than a simple average, of the GoDaddy variables. This index and methodology is explained in a forthcoming special report about online microbusinesses.