

The Effect of COVID-19 Immigration Restrictions on Post-Pandemic Labor Market Tightness

Maggie Isaacson, Cassie Marks, Lowell Ricketts, and Hannah Rubinton

Abstract

During the COVID-19 pandemic, there were unprecedented shortfalls in immigration. Concurrently, as the economy recovered, the labor market was tight, with the number of vacancies per unemployed worker reaching two, more than twice its pre-pandemic average. In this article, we investigate whether these two trends are connected. We find no evidence to support the hypothesis that the immigration shortfalls caused the tight labor market, for two reasons. First, while there was a deficit of about two million immigrant workers at the peak, this number had largely recovered by February 2022, just as the labor market was becoming tight. Second, states, cities, and industries that were most impacted by the immigration restrictions did not have larger increases in labor market tightness. We construct a shift-share instrument to examine the causal impact of the immigration restrictions and still find no evidence supporting the hypothesis that they were the underlying cause of increased labor market tightness.

Keywords: COVID-19, Immigration, Wages

JEL Codes:

J61, J20, J40

1. INTRODUCTION

During the COVID-19 pandemic, there was an unprecedented slowdown in immigration. Travel restrictions and border closures were some of the earliest measures implemented to stop the spread of COVID-19. Subsequent immigration restrictions were implemented with the more explicit goal of protecting domestic workers during the economic recovery from the COVID-19 recession. In April 2020, President Trump issued an executive order suspending all work visas, citing a “risk to the labor market during the economic recovery” (Trump, 2020b). These actions led to a large drop in immigrant workers.

Later during the economic recovery from the COVID-19 recession, the labor market became unprecedentedly tight. By March 2022, there were 2 job openings for every unemployed worker. This vacancy-to-unemployment ratio, or the VU ratio, is a common measure of labor market tightness. Before COVID-19,

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between 2015 and 2019, the VU ratio averaged 0.93 (Labor Statistics, Labor Statistics).

The simultaneous decline in immigration and increase in labor market tightness led many researchers and policymakers to question the role of the immigration slowdown in causing labor market tightness. For example, in a speech at the Brookings Institution in November 2022, Chairman Powell claimed that the economy was facing a current labor force shortfall of 3.5 million people, of which “the combination of a plunge in net immigration and a surge in deaths during the pandemic probably accounts for about 1–1/2 million missing workers” (Powell, 2022).

In this article, we examine whether the decline in immigration during the COVID-19 pandemic is responsible for the tight labor market during the recovery. To do this, we construct measures of missing immigrant workers in the aggregate and across cities, states, and industries. Our findings do not support the hypothesis that these missing workers significantly affected labor market tightness for two reasons. First, we find that the number of missing workers is not large enough to have had a significant aggregate impact, and this number had recovered before labor market tightness increased. Second, we find no evidence that cities, states, or industries that were most impacted by the immigration restrictions also had the largest increase in labor market tightness.

We start our analysis by discussing the measurement of missing workers. We define an “immigrant worker” as a working-age individual who is in the labor force and not a U.S. citizen. We then create a measure of the number of immigrant workers that are “missing.” Using data from the Current Population Survey (CPS) and the American Community Survey (ACS), we begin by counting the number of immigrant workers over time. We create a trend line from 2011 to 2019 and then project the trend line forward to the present day. The difference between the projected trend line and the actual number of immigrant workers is our measure of missing workers. Namely, it is our projection of the number of immigrant workers who would have been in the country if the pre-COVID-19 trend had continued uninterrupted, minus the number of workers who were actually present.

There is substantial heterogeneity across cities, industries, and states in the extent to which they were impacted by the immigration restrictions. To measure the missing workers in each labor market, we repeat the same procedure for each city, state, or industry separately. We then normalize the number of missing workers by the size of the pre-pandemic labor market to compute the share of the pre-pandemic labor force that is missing due to the restrictions. Next, we compute several labor market outcomes, including labor market tightness, measured by the VU ratio and wage growth.

Using our measures, we examine whether industries, states, or cities that had the most missing immigrant workers were also the labor markets that experienced the largest increase in labor market tightness. In no case do we find a significant positive correlation, meaning that industries, states, and cities with the most missing workers did not systematically experience larger increases in the VU rate or larger wage growth.

While the correlations are suggestive evidence that the missing immigrants are not driving the changes in labor market tightness, the correlations could be obscuring the true causal impact of immigration restrictions. In particular, this would be the case if immigrants who are unaffected by the restrictions reallocate toward tight labor markets, which would bias our estimate toward zero. To further investigate this finding, in Section 5, we use a shift-share instrument that predicts a labor market’s missing workers based on the country of origin of their existing immigrant workforce, interacted with the aggregate changes in immigrants from that country of origin, following Card (2009). Using this approach, we still do not find evidence to support the causal impact of immigration restrictions on labor market tightness.

We note that our null result does not definitively mean that immigration restrictions did not impact labor market tightness. It is possible that a researcher armed with more detailed data, allowing a more granular analysis, would find such an effect. However, we conclude that our data do not support the hypothesis that restrictions are the underlying cause of tight labor markets.

2. EXISTING LITERATURE

This article contributes to two strands of existing literature. First, several papers attempt to explain the recent increase in labor market tightness during the recovery from the COVID-19 pandemic. A few explanations stand out. Some scholars attribute the post-pandemic labor market tightness to early retirements (Faria-e-Castro, 2021), while others point to decreasing female labor force participation rates (Bick, Gregory, and Leukhina, 2023). Related work looks at the increase in workers claiming disability (Michaud, 2020). We complement these papers by examining the impact of immigration restrictions. These explanations are not mutually exclusive, as all of these channels are likely impacting the labor supply simultaneously.

Second, this article contributes to a strand of literature focusing on the impact of COVID-19 on immigration and its subsequent impact on the labor market (Cohen and Shampine, 2022; McKay, 2023; Peri and Zaiour, 2022). Specifically, these papers find a correlation between an industry's pre-COVID-19 reliance on foreign-born workers and the rate of unfilled vacancies in an industry. However, Butcher et al. (2023) do not find that foreign-born intensive industries were those that had larger increases in recruiting intensity, an alternative measure of labor market tightness. Most notably, Peri and Zaiour (2023) find that during the COVID-19 pandemic, immigration to the U.S. significantly declined. However, similar to us, they find that the immigration shortages had no significant impact on the internal migration rates of domestic workers. We extend their analysis by examining the effects of decreased immigration on post-pandemic labor market tightness, exploring them at the state, industry, and city levels.

More broadly, in the extensive literature on the effect of immigration on labor markets, reviewed by Lewis and Peri (2015), there is considerable debate on whether immigrants negatively impact the labor market outcomes of native workers (Card, 2001; Card, 2009; Friedberg and Hunt, 1995; Ottaviano and Peri, 2012; Borjas, 2003). Our finding that the immigration shock is unlikely to have impacted local labor market tightness is consistent with previous studies that find that immigrant workers are imperfect substitutes for native workers and therefore minimally impact their labor market outcomes.

3. MEASUREMENT

In this section, we discuss the data and methods we use to measure the number of missing immigrant workers and labor market tightness. Section 3.1 discusses the data on immigration and the measure of missing workers, while Section 3.2 discusses the data on labor market outcomes.

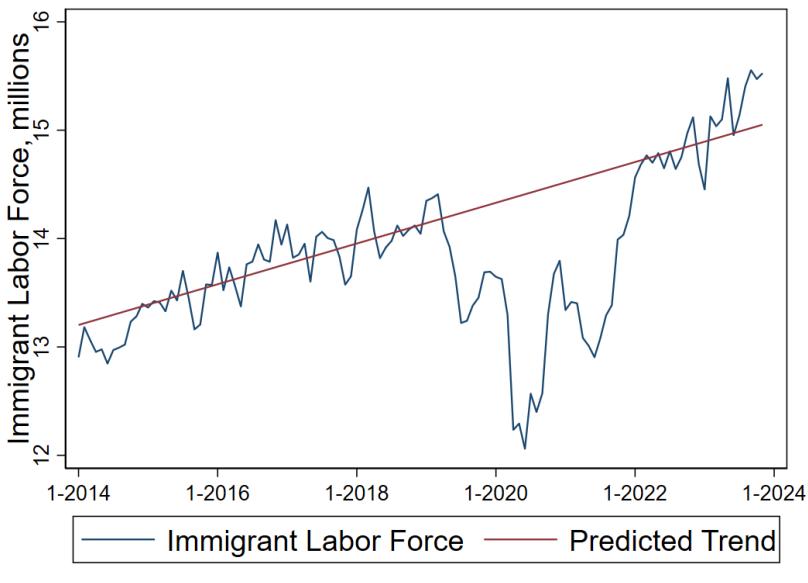
3.1 Measuring the Missing Immigrants

In this section, we discuss how we measure missing immigrant workers. We use two data sources to count the number of workers. First, we use the CPS to look at aggregate trends. CPS offers the most up-to-date data that include workers' citizenship status. Second, we use the one-year ACS for analysis across industries, states, or cities due to its larger sample size. Unfortunately, the ACS is annual and, at the time of this writing, was only available through 2022. We follow the same sample selection procedures and methods for calculating the number of missing workers in both datasets.

We define an immigrant worker as a worker who is not a U.S. citizen. This definition is different from other studies that count any foreign-born worker as an immigrant regardless of their citizenship status. As a result, we find a much smaller number of immigrant workers.¹ For example, in July 2022, we count approximately 15 million non-U.S. citizen workers, while Peri and Zaiour (2023) count approximately 39 million foreign-born workers. We focus on non-U.S. citizen workers since they are much more likely to have been impacted by COVID-19 immigration restrictions, while citizens always have the right to enter the U.S. regardless of where

1. We acknowledge that naturalizations were halted during the beginning of the pandemic, which may inflate our immigrant worker count. Our estimate should be interpreted as a lower bound, as our measure of immigrants will appear higher than it would have if the naturalizations had continued uninterrupted.

Figure 1 Immigrant Labor Force



Source: CPS and authors' calculations.

they were born. We restrict our sample to working-age (ages 18 to 65) individuals who are in the labor force, and we drop workers who are in the armed forces.

Figure 1 plots the number of immigrant workers, as counted in the CPS, showing a significant drop in 2020 during the COVID-19 pandemic. By June 2020, the number of immigrant workers drops to 12.06 million. However, by January 2022, it quickly recovers to its pre-COVID-19 peak of 14.47 million.

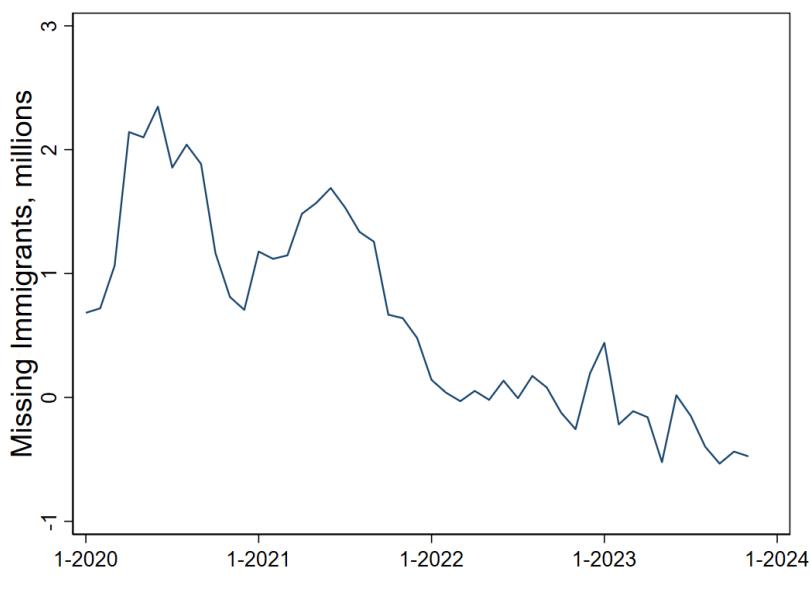
Next, we measure the number of immigrant workers who were missing due to the COVID-19 pandemic. We predict how many immigrant workers there would have been based on the pre-pandemic trend (2011 to 2019), shown as the red line in Figure 1. Then, we calculate the missing immigrant workers as the difference between the predicted number and the actual number. Before the pandemic (2015–19), there was an average of 14 million immigrant workers. From 2011 to 2019, the average growth rate of immigrant workers was 0.8 percent per year. If this had continued without pandemic immigration barriers, in June 2021, there would be 14.6 million immigrant workers; instead, there were 12.9 million.

Figure 2 plots the number of missing immigrant workers, which peaked in June 2020 at 2.35 million and recovered by February 2022. In 2023, the average number is negative, indicating there are more immigrant workers than the trend. In other words, the number of immigrant workers in the U.S. has now surpassed where it would have been if the pre-COVID-19 trend had continued.

Both Figures 1 and 2 show the aggregate trends. However, there is substantial heterogeneity across different segments of the economy. To address this, we look across states, cities, and industries. The number of missing workers is measured using the previously described method but separately for each state, city, or industry. We then normalize the number of predicted missing workers by the size of the state, city, or industry's 2019 labor force. When analyzing across cities, we limit our analysis to the 100 largest cities. For smaller cities, the sample size of immigrant workers in the ACS becomes too small.

Figure 3 shows missing immigrant workers as a percentage of the 2019 labor force across states, cities, and industries. Panel (a) shows missing immigrant workers by state. Unsurprisingly, states such as Texas, Arizona, and Florida, which traditionally have high immigration flows, have a high share of missing immigrant workers, while Idaho, Montana, and Kansas have relatively few missing workers. However, we also observe

Figure 2 Missing Immigrant Workers



Source: CPS and authors' calculations.

that states such as Iowa and Nebraska are heavily impacted. Nevada, for example, has a labor force of about 1,475,087 people in 2019. Compared to their pre-pandemic trend, they are missing 23,407 immigrant workers, meaning that about 1.59 percent of its pre-pandemic labor force is missing due to immigration restrictions. Conversely, in some states, such as West Virginia and North Dakota, the number of immigrant workers has actually surpassed its pre-pandemic trend. As a result, our estimate of missing workers due to the COVID-19 restrictions is negative.

Panel (b) shows missing immigrant workers by city, defined as core-based statistical areas (CBSAs). Cities such as Walla Walla, WA; Key West, FL; and Ames, IA have a higher percentage of missing immigrant workers, while others such as Madisonville, KY; Thomaston, GA; and Asheville, NC have fewer missing workers. Some cities, such as Arcadia, FL; El Centro, CA; and Goldsboro, NC have more immigrant workers than we predicted, resulting in a negative number of missing workers.

Finally, panel (c) breaks down missing workers by industry, showing substantial heterogeneity in missing immigrant workers by industry. On the one hand, some industries, such as administration and transportation and warehousing, have an above-trend number of immigrant workers (shown as a negative number of missing immigrant workers). On the other hand, the mining, quarrying, and oil and gas extraction industry and the accommodation and food services industry are most impacted. They are missing upwards of 2 percent of their 2019 labor force.

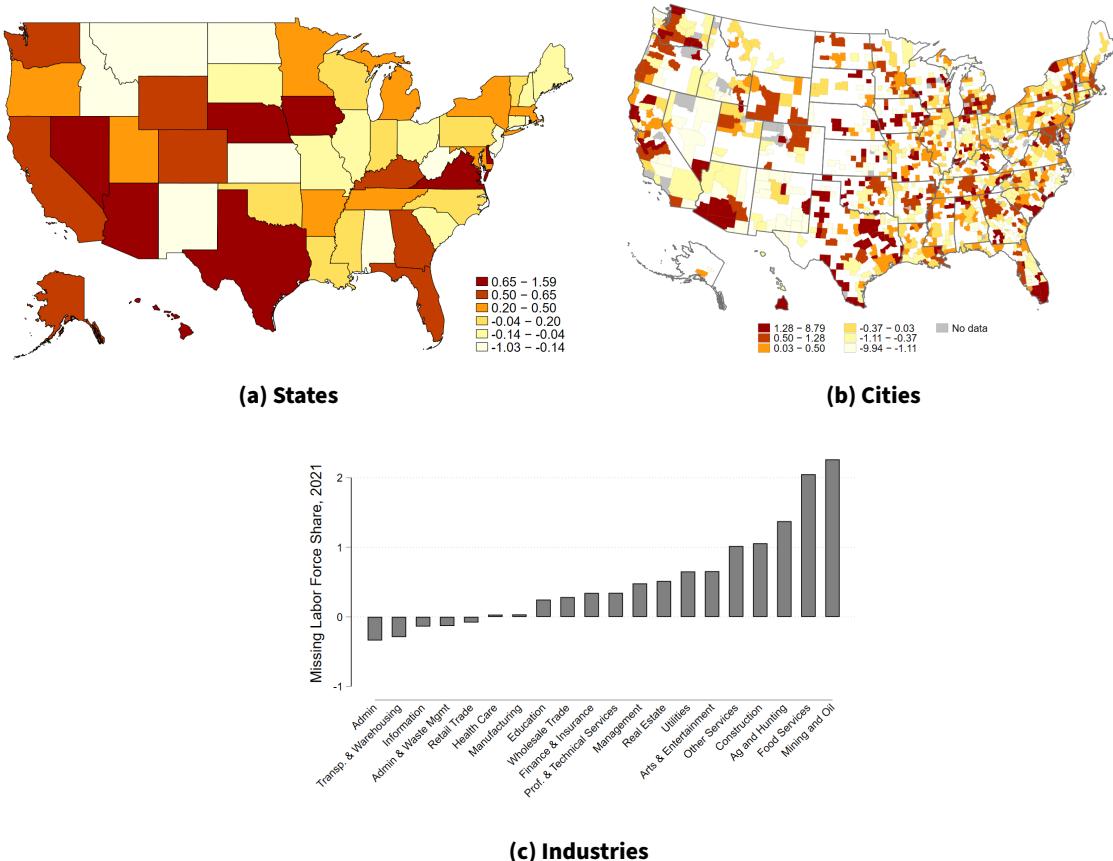
3.2 Measuring Labor Market Outcomes

In this section, we discuss the measures of labor market outcomes that we use in our analysis. We look at two main measures of the labor market: the VU ratio and wage growth.

3.2.1 The VU Ratio

As our main measure of labor market tightness, we use the ratio of the number of vacancies to unemployed persons, known as the VU ratio. To measure vacancies, we use data from two sources based on the level of disaggregation required. For aggregate vacancies and when analyzing across states and industries, we use data from the Job Openings and Labor Turnover Survey (JOLTS). Because the JOLTS survey is not available at the city level, we obtain data on job openings from LinkUp, a firm that collects job listings directly from more than

Figure 3 Missing Workers



Source: JOLTS, CPS, and authors' calculations.

60,000 employer websites. Because LinkUp is a new dataset, we first validate the data by comparing them to the JOLTS data at the state level. In Appendix B, we further discuss the LinkUp data, show the correlations of job openings in LinkUp and JOLTS across states, and describe how we measure city-level vacancies (Marks et al., 2023). To measure unemployment, we use the CPS for the aggregate series, the ACS for state- or industry-level analysis, and the Local Area Unemployment Statistics (LAUS) for city-level analysis.

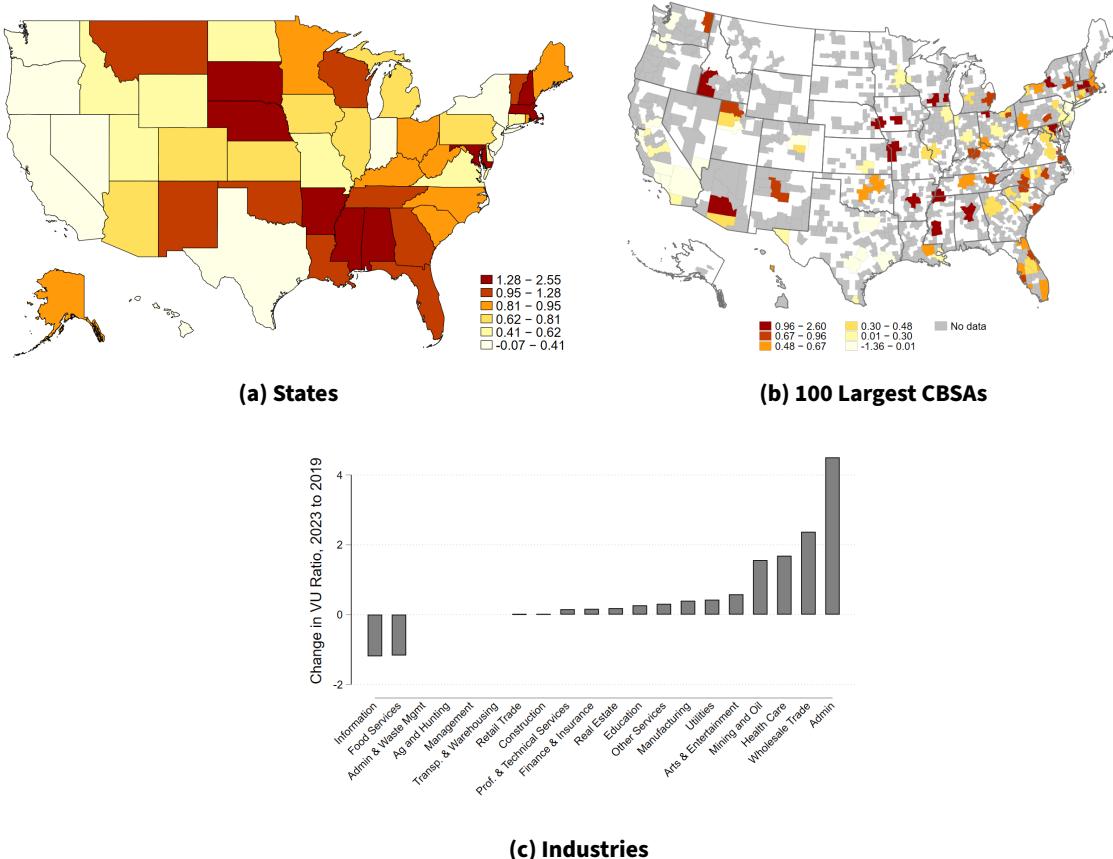
Appendix Figure A.2 shows the VU ratio levels in May 2023 across cities, states, and industries, illustrating where labor market tightness increased the most since 2019. To determine how the VU ratio has changed since the pandemic, we take the difference between the 2019:Q2 and 2023:Q2 VU ratios (specifically, we take the average of the April, May, and June VU ratios of 2019 and 2023 for states, cities, and industries²). Figure 4 shows these changes, with panel (a) by state, panel (b) by the top 100 most populous CBSAs, and panel (c) by industry. At the state level, South Dakota and Alabama see the largest increase in labor market tightness. At the city level, Jackson, MS and Omaha-Council Bluffs, NE-IA have the largest increases in labor market tightness. By industry, wholesale trade and administration see the largest increase in its VU ratio.

3.2.2 Wage Growth

Wage growth is another indicator of labor market tightness. In tight markets, employers may raise wages to attract more workers. To examine wages, we use data from the Quarterly Census of Employment and Wages (QCEW). We then compute wage growth between the total quarterly wages of 2019:Q2 and 2023:Q2 for each geographic area of interest. Appendix Figure A.1 shows which cities, states, and industries have the highest

2. For cities, we use the difference between the May 2019 and May 2023 VU ratio.

Figure 4 Change in the VU Rate



Source: JOLTS, CPS, LinkUp, and authors' calculations.

wage growth, the details of which can be found in Appendix A .

4. MISSING IMMIGRANTS AND THE LABOR MARKET

In this section, we examine the impact of the missing immigrant workers on the labor market. First, in Section 4 .1, we compute simple counterfactuals examining the aggregate impact of missing workers on the labor market. Then, in Section 4 .2, we explore whether the number of the share of missing workers is correlated with labor market outcomes across states, cities, and industries.

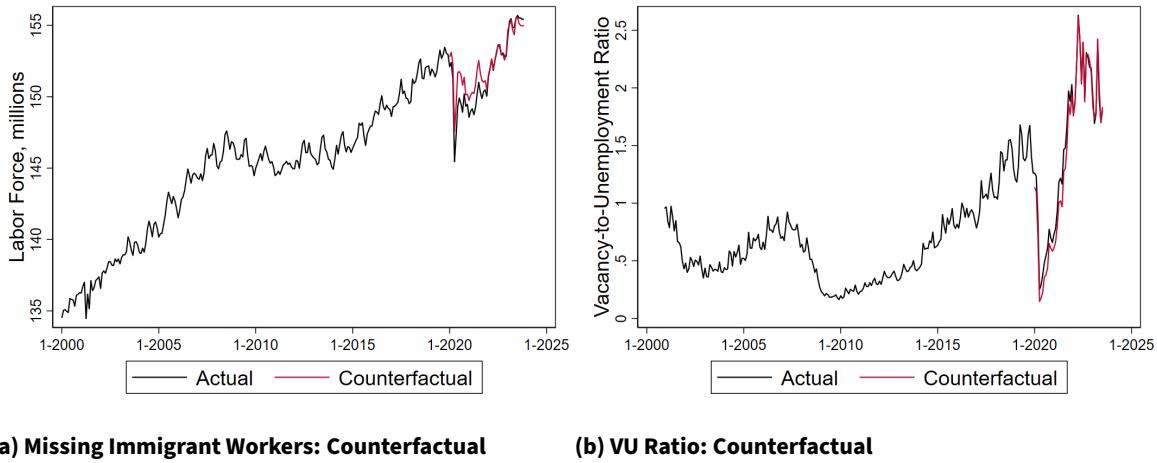
4.1 The Aggregate Impact of Missing Workers

In this section, we use our measure of missing immigrant workers to examine the aggregate impact of immigration restrictions. We compute two simple counterfactuals asking what would have happened to the aggregate labor force and the aggregate VU ratio if immigration had continued uninterrupted.

Figure 5 shows the aggregate impact of the missing immigrant workers on the labor force. To calculate the counterfactual, we add the missing immigrant workers back to the labor force. The results, shown in Panel (a) of Figure 5, indicate a small effect from adding these workers back to the labor force. Specifically, the labor market would have returned to 2019 levels in July 2021 rather than March 2022. Moreover, recent differences between the counterfactual and the actual number of workers are small.

We then compute a counterfactual VU ratio as if immigration had continued uninterrupted. Specifically, we

Figure 5 Aggregate Impact of Missing Immigrant Workers



(a) Missing Immigrant Workers: Counterfactual

(b) VU Ratio: Counterfactual

Source: CPS and authors' calculations.

Note: In panel (b), the VU ratio differs slightly from the VU ratio reported by the U.S. Bureau of Labor Statistics (BLS), as our sample selection differs from the BLS. We restrict our sample to working-age (ages 18 to 65) and we drop workers who are in the armed forces.

assume each immigrant worker would fill one vacancy while leaving the number of unemployed unchanged.³ Panel (b) shows the results. The immigrant labor force had already recovered by the time labor market tightness peaked, with the biggest impact on the VU ratio occurring in early 2020 when it was still below its pre-pandemic level. By the time the labor market became tight, the level of immigration had already recovered. Both the actual and the counterfactual show similar VU ratios, suggesting that the missing immigrant workers did not drive aggregate labor market tightness.

4.2 Missing Immigrants across Labor Markets

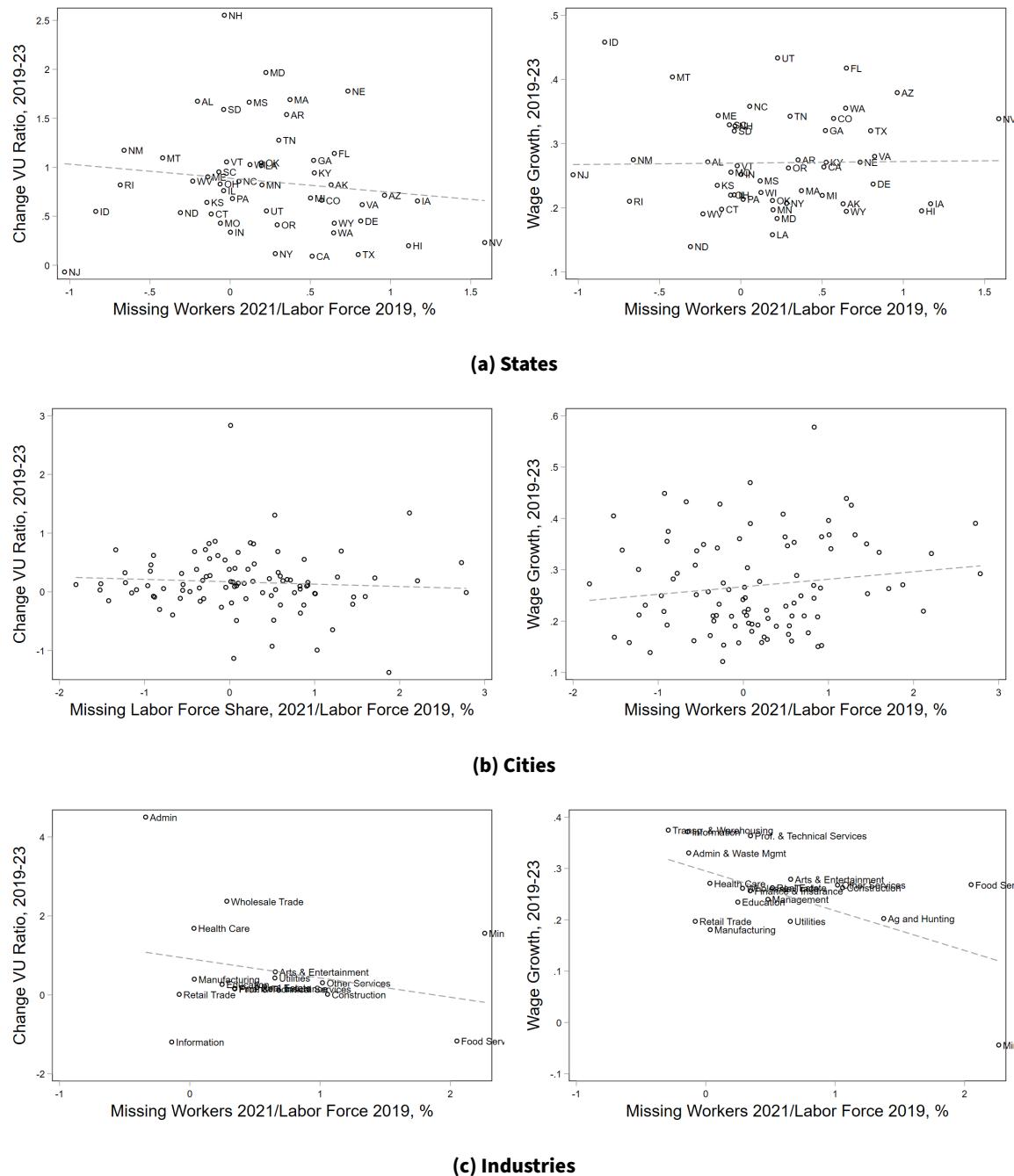
Next, we examine the impact of immigration restrictions on specific labor markets, investigating whether the states, cities, and industries most impacted by the restrictions also experienced the largest increases in labor market tightness, as measured using the VU ratio and wage growth.

The left side of Figure 6 plots correlations between the 2019 to 2023 change in the VU rate and the 2021 share of missing immigrant workers from the 2019 labor force. Panel (a) shows the correlations by state, panel (b) for the 100 largest cities, and panel (c) by industry. In no case is there a correlation between the share of the 2019 workforce that is missing due to immigration restrictions and the change in the VU ratio. The markets with the most missing workers—industries such as accommodation and food services and mining, or states such as Nevada and Iowa—are not the same markets that had the largest increase in the VU ratio—industries such as administration and wholesale trade and states such as New Hampshire and Maryland. Appendix Figure A.3 shows that the correlations look similar when examining the changes in the VU ratio between 2019 and 2022 instead of between 2019 and 2023.

Next, we examine our second measure of labor market tightness: wage growth. The right side of Figure 6 plots correlations between wage growth and the share of missing immigrant workers from the 2019 labor force. As with the change in the VU ratio, there is no statistically significant positive correlation between wage growth and the share of missing workers. In fact, across industries, the relationship is negative, driven particularly by lower wage growth in the mining sector. The correlations between missing workers and wage growth between 2019 and 2022 are shown in Appendix Figure A.3 and appear similar.

3. Instead, we could assume that each immigrant worker would add to the stock of unemployed workers. The counterfactual in this case would be similar.

Figure 6 Correlations between Missing Immigrant Workers and Changes in Labor Market Measurements



Source: JOLTS, CPS, and authors' calculations.

Overall, we do not find that labor markets most impacted by immigration restrictions also had the largest increase in the VU ratio or the highest wage growth. Although correlations between changes in the VU ratio and missing immigrant workers suggest a causal relationship, they are not enough to definitively state whether the missing immigrant workers do or do not have a causal effect on labor market tightness. In other words, these correlations could be obscuring the true causal impact of immigration on labor market tightness. To further investigate this issue, we use an instrumental variable (IV) approach in the following section to examine

the causal impact of immigration restrictions on the labor market.

5. CAUSAL ANALYSIS

The previous correlations do not reflect the causal impact of the immigration restrictions on labor market tightness. There are several reasons why the correlations could obscure the true impact of immigration on the labor market. For example, if immigrants who are allowed to remain in the U.S. move toward the tightest labor markets, then it will appear as if these markets have not been affected by the immigration restrictions. To address this issue, we develop a shift-share instrument to examine the causal impact of these restrictions on local labor market tightness. Our instrument builds on the work of Peri and Zaiour (2023) and Card (2009), who both use shift-share instruments based on immigrants' countries of origin.

We start by grouping immigrants into 51 categories by country of origin, consisting of the 50 countries with the largest immigration flows, with all remaining countries combined into the 51st "other" category. Then, for each country of origin, o , we calculate the number of missing workers (as described in Section 3.1) for the U.S. as a whole. Specifically, for each origin country, we compute the time trend of immigrant flows between 2011 and 2019. We project this trend forward and compute missing immigrants from country o as the predicted number of immigrants minus the actual number, $X_{ot} = \hat{I}_{ot} - I_{ot}$. We interact this imputed value with the share of immigrants from country o who live in state or city g in 2010, $S_{og,2010}$ to create the shift-share instrument:

$$F_{gt} = \frac{\sum_o S_{og,2010} X_{ot}}{Pop_{g,2010}},$$

summing across the countries of origin. Thus, the numerator reflects the predicted number of missing immigrants for each state or city, g , based on the number of immigrants missing from country o and the share of immigrants from country o who lived in state or city g in 2010. Finally, we normalize by the state or city population in 2010 so that the instrument reflects the predicted missing immigrants as a share of the state or city's 2010 population.

For our instrument to be valid, we need either one of two conditions to hold. The first condition is that the initial immigrant shares are uncorrelated with the changes in labor market tightness that we are interested in measuring (Goldsmith-Pinkham, Sorkin, and Swift, 2020). This condition is unlikely to hold, as immigrants often work in certain industries that are geographically concentrated (such as agriculture), and these industries may have been differently affected by the pandemic. However, even if this first condition does not hold, the instrument would still be valid under the second condition: if the initial shares are uncorrelated with the national immigration shocks (Borusyak, Hull, and Jaravel, 2022). Since the immigration shocks were driven by the response to the plausibly exogenous COVID-19 shock, we believe this second condition is likely to hold. This condition presumes that the immigration shock affected immigrants from various countries of origin differently, and these differences are uncorrelated with local country-of-origin immigration shares. For example, one of the first immigration acts suspending entry of all immigrants from China, was motivated by fear of the disease rather than by the potential labor market impacts in certain geographic areas (Trump, 2020a).

We run two IV regressions, examining the impact of missing immigrant workers on a state or city's change in the VU ratio or wage growth, instrumenting the missing immigrant share in 2021 with our shift-share instrument. Table 1 shows the results at the state level in Panel A and the city level in Panel B. In both cases, the instrument is predictive of the true missing workers share, and the first stage has an F-stat well over 10. The results are similar whether we look across cities or states.

Column 2 shows the causal effect of the missing immigrants on the change in the VU ratio between 2019 and 2023. A 1-percentage-point increase in the share of the missing labor force leads to a 0.8-percentage-point decrease in the VU ratio. In other words, the coefficient is the opposite of what would be expected if

the missing immigrant workers caused an increase in labor market tightness. How do we explain the negative coefficient? One possibility is that states or cities most affected by the immigration shock had systematically different industry compositions. For example, the COVID-19 shock might have eliminated relatively more vacancies in cities that were concentrated in the service sector, where jobs are typically filled by immigrant workers. Controlling for broad industry composition weakens the first stage of the IV regression but does not meaningfully impact the results.

Column 3 shows the causal impact of missing immigrants on average wage growth between 2019 and 2023. Here we see the opposite effect: While the coefficient is not statistically significant across states, cities most affected by the missing workers also experience a larger wage growth. This is what would be expected if the missing workers had caused an increase in labor market tightness, putting upward pressure on wages. Specifically, a 1-percentage-point increase in the share of the missing labor force corresponds to a 0.05-percentage-point increase in average wage growth. Thus, we do find some evidence to support the hypothesis that the immigration restrictions led to faster wage growth, but overall, the results across cities, states, industries, and different measures of labor market tightness are mixed.

6 . CONCLUSION

In this article, we examine the impact of immigration on post-pandemic labor market tightness. Overall, we do not find support for the hypothesis that the immigration slowdown is responsible for the tight labor markets post-COVID-19. We conclude this for two reasons. First, analyzing the aggregate data reveals that the number of immigrant workers had returned to pre-pandemic levels before the large increase in labor market tightness. Plotting a simple counterfactual shows that the impact of the immigration restrictions on the labor force and VU ratio would have been minimal. Although the number of missing immigrant workers was large during the early part of the pandemic, it had largely recovered by the time the labor market had become tight in 2022. Second, we do not find that states, cities, or industries most impacted by immigration restrictions also had large changes in wage growth or their VU ratio. Further, we use a shift-share instrument to investigate the causal relationship between a decline in immigration and labor market tightness. We run two IV regressions examining the impact of missing immigrant workers on a state or city's change in the VU ratio or wage growth. The regression results also do not support the hypothesis that immigration restrictions were the underlying cause of labor market tightness.

Based on our analysis and data, we do not find support for the hypothesis that missing immigrant workers drove the increased post-pandemic labor market tightness. However, we note that our null result does not definitively mean that the immigration restrictions had no impact on the post-pandemic labor market. Our study is limited by the sample sizes of the underlying data, which prevent an analysis at finer levels of disaggregation. Future research, perhaps with more detailed data, may find an impact, particularly in certain labor markets and industries.

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Table 1 IV Regressions

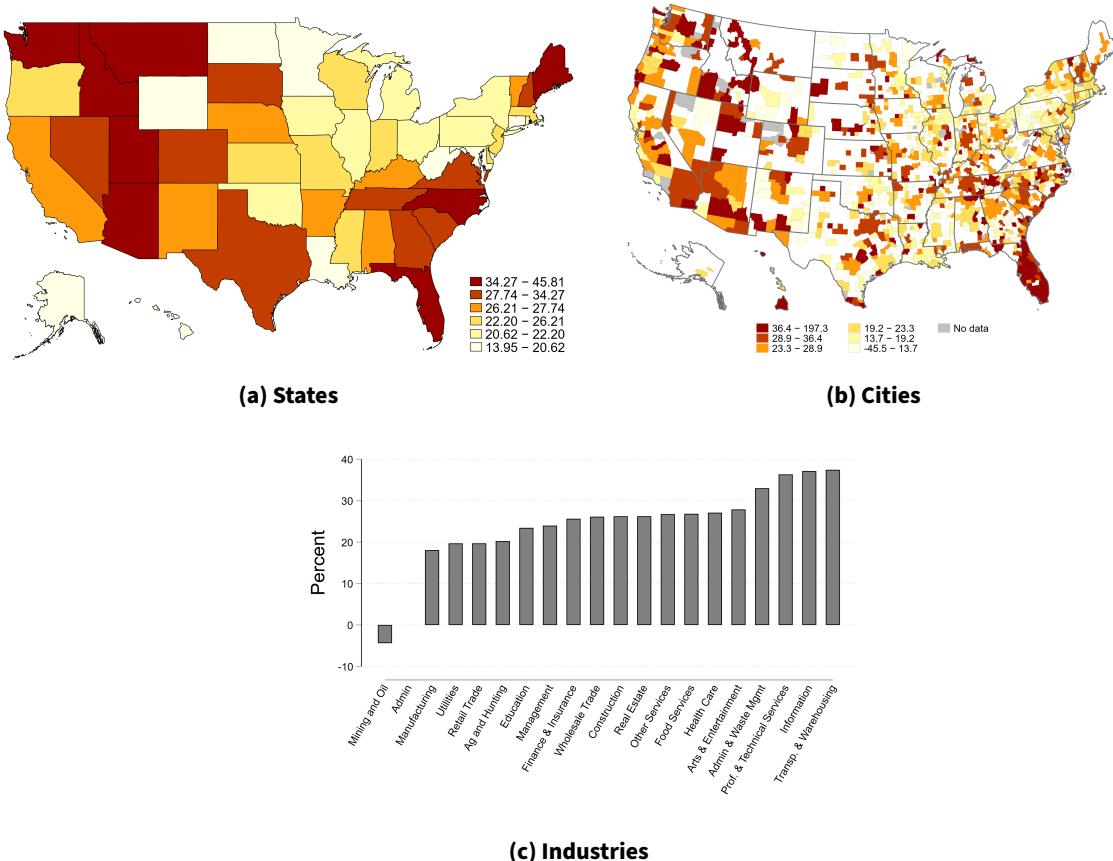
Variables	Panel A: States		
	(1)	(2)	(3)
	First	Second	Second
Variables	Missing LF Share (2021)	Ch. in VU Ratio (2019-23)	Wage Gr. (2019-23)
Instrument Missing Workers (2021)	1.861*** (0.453)		
Missing LF Share (2021)		-0.755** (0.331)	0.0612 (0.0429)
Constant	-0.0598 (0.0932)	1.023*** (0.113)	0.257*** (0.0146)
Observations	50	50	50
R-Squared	0.260		
IV F-Stat	16.85		
Durbin p-val	0.0122		
Variables	Panel B: Cities		
	(1)	(2)	(3)
	First	Second	Second
Variables	Missing LF Share (2021)	Ch. in VU Ratio (2019-23)	Wage Gr. (2019-23)
Instrument Missing Workers (2021)	1.710*** (0.387)		
Missing LF Share (2021)		-0.734*** (0.225)	0.0524** (0.0257)
Constant	-0.191 (0.118)	0.607*** (0.0934)	0.261*** (0.0107)
Observations	96	96	96
R-Squared	0.172		
IV F-Stat	19.52		
Durbin p-val	3.40e-07		

Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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Figure A.1 Wage Growth 2019–23



Source: JOLTS, CPS, and authors' calculations.

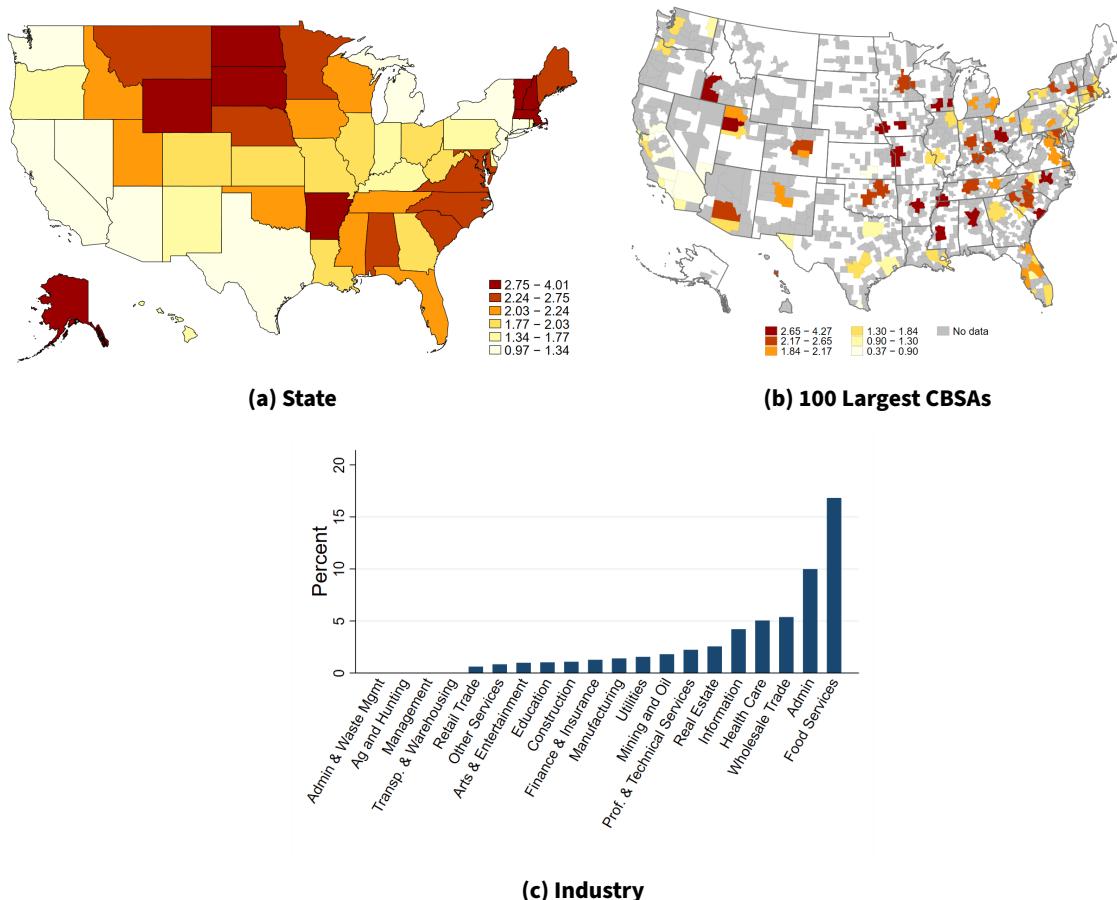
A. ADDITIONAL DATA FIGURES

In this section, we include several additional figures that could not be included in the main text. First, Figure A.1 shows wage growth across states, cities, and industries. States with the highest wage growth include Idaho, Utah, and Florida, and industries with the highest wage growth are transportation and warehousing and information.

In the main text, we show in Figure 4 the states, cities, and industries with the largest increase in the VU ratio. However, these are not necessarily the tightest labor markets. In Figure A.2, we show the states, cities, and industries that had the highest VU ratio in May 2023. States with the highest VU ratio include Oklahoma, Wyoming, South Dakota, and North Dakota, and accommodation and food services and administration are the tightest industries.

Additionally, we reproduce some of the main results with an alternate time period. In Figure 5 of the main text, we plot missing immigrant workers with the change in the VU ratio and wage growth between 2019:Q2 and 2023:Q2, respectively, at the state, city, and industry level. Figure A.3 shows the same correlations but with the change in the VU ratio and wage growth from 2019:Q2 to 2022:Q2, respectively. We see similar correlations to those in the scatter plots that depict the change from 2019 to 2023, and find little to no positive correlation at the state, industry, and city levels. This finding further supports our conclusion that missing immigrant workers did not drive labor market tightness or wage growth.

Figure A.2 May 2023 VU Ratio



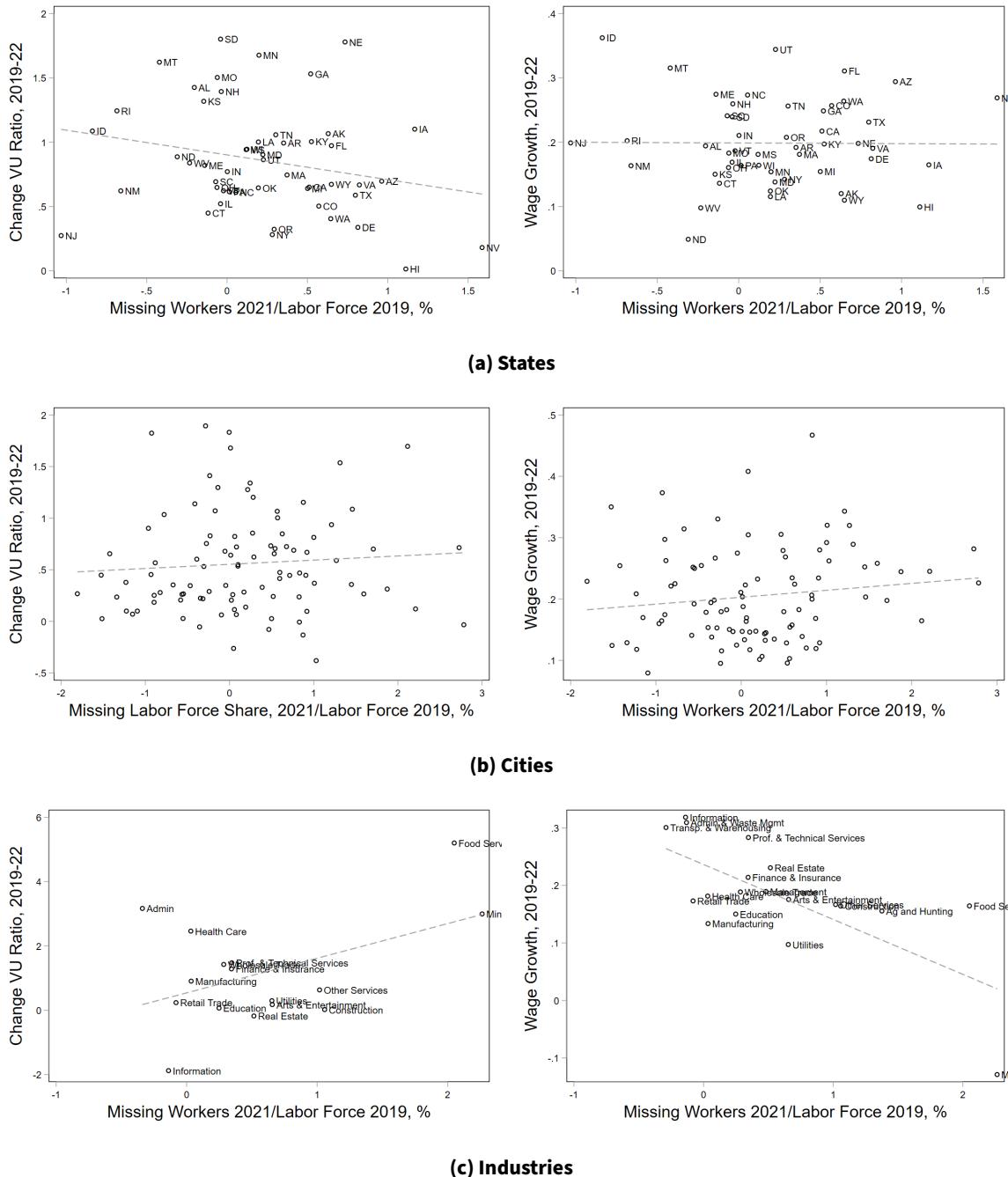
Source: JOLTS, CPS, and authors' calculations.

B. COMPARING JOLTS AND LINKUP DATA

To measure city-level vacancies, we use LinkUp data. Some of this data description and analysis first appeared in Marks et al. (2023). LinkUp is a company that collects and analyzes job data directly from over 60,000 employer websites, indexing 25,000 websites every 24 to 48 hours. Once observed, a job listing is assigned a unique identifier and tracked for the remainder of time that it appears on the employer's website. While much of the data collection is performed via automated processes, LinkUp staff work to clean the data to ensure and maintain quality. For example, in instances where a job record disappears and then reappears, if the collective information suggests that the job is not unique, LinkUp processes will assign the same unique ID as it had when it first appeared. Separately, LinkUp staff seek to address situations in which employers change how they list job openings in ways that impact data collection. For example, when a major technology company switched from listing job openings for support staff individually by store to a single job portal, LinkUp staff identified this change and adjusted the collection process accordingly.

While this dataset is powerful, there are some potential caveats. One concern is that increases in overall job listings might not be caused by actual job creation; rather, it could be driven by increasing coverage of the employer universe via LinkUp's continued expansion of web-scraping efforts. However, LinkUp's sample of employers is primarily composed of (although not limited to) those included in major financial indexes (e.g., S&P 500, Russell 1000). Given that the sample has achieved close to 100 percent coverage of employers represented in these major financial indexes, it is relatively stable and captures job listings for the largest corporate

Figure A.3 Correlations between Missing Immigrant Workers and Labor Measurements



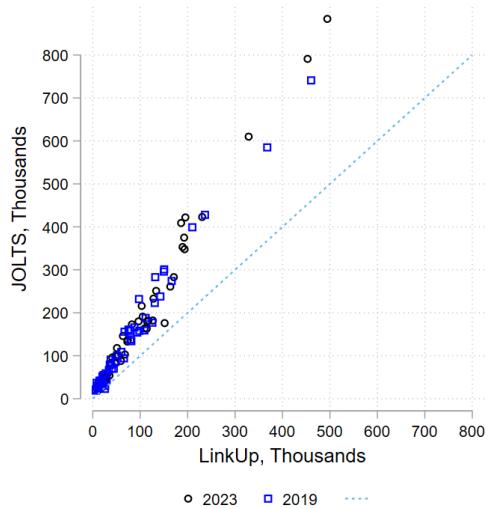
Source: JOLTS, CPS, and authors' calculations.

employers in the U.S.

Another concern is that the difference in job listings in the LinkUp data is capturing institutional features of the company as opposed to true variation in job listings. For example, LinkUp may have more contacts in Minnesota, where it is headquartered, than other states. To address this concern, we first validate the data by comparing the state-level job listings in LinkUp with JOLTS, which is nationally representative.

Figure A.4 shows the job openings in JOLTS compared with job listings in the LinkUp data. The correlation between the JOLTS and LinkUp data is 0.99 for May 2019 and 2023, suggesting that the LinkUp data are

Figure A.4 Correlation between JOLTS and LinkUp Job Openings



Source: JOLTS and LinkUp Data.

capturing variation in the number of job listings across states, not variation in the popularity of the company based on region. This high correlation gives us confidence that when we use the LinkUp data to measure job listings at the city level, they will capture true local variation in job listings.

Notably, the LinkUp data do not capture all the job openings reported in JOLTS. In Figure A.4, the dashed line indicates a 45-degree line: If the LinkUp data and JOLTS data were identical, all points would lie along this line. Although the LinkUp data are highly correlated with JOLTS, the level of job listings differ. The points lie above the 45-degree line, indicating that the LinkUp data are missing vacancies present in JOLTS. On average, the LinkUp data are missing 46 percent of the vacancies reported across all states. The share of missing job openings is not systematically correlated with a state's population; both large and small states are missing around 46 percent of vacancies. However, this means that in levels, the LinkUp data are missing more job listings in larger states than in smaller ones, as 46 percent of a large number is larger. Thus, we scale the vacancies in each state or city by the state-level error in 2019, which is defined as the percentage of the state's JOLTS job openings that are missing in the LinkUp data. This scaling is necessary so that we correctly measure the level of the VU ratios in our analysis in Sections 4.2 and 5. We have redone the analysis without the scaling, and it makes little difference in the cross-sectional results.