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Authors	Maggie Isaacson, Cassie Marks, Lowell R. Ricketts, and Hannah Rubinton
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Federal Reserve Bank of St. Louis, Research Division, P.O. Box 442, St. Louis, MO 63166

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Where Did the Workers Go? The Effect of COVID Immigration Restrictions on Post-Pandemic Labor Market Tightness

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

Abstract

During the COVID pandemic there were unprecedented shortfalls in immigration. At the same time, during the economic recovery, the labor market was tight, with the number of vacancies per unemployed worker reaching 2.5, more than twice its pre-pandemic average. In this paper, we investigate whether these two trends are linked. We do not find evidence to support the hypothesis that the immigration shortfalls caused the tight labor market for two reasons. First, at the peak, we were missing about 2 million immigrant workers, but 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 build a shift-share instrument to examine the causal impact of the immigration restrictions and still find no evidence to support the hypothesis that the immigration restrictions 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. One of the first actions taken as a precaution against the spread of COVID was closing the borders, both abroad and domestically. Later immigration restrictions became more explicit to protect domestic workers during the recovery from the COVID recession. In April 2020, then-President Trump issued an executive order suspending all work visas because immigration posed 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 recession, the labor market became unprecedentedly

Hannah Rubinton is an Economist at the Federal Bank of St. Louis, Maggie Isaacson is a Senior Research Associate at the Federal Reserve Bank of St. Louis, Cassie Marks is a Research Associate at the Federal Reserve Bank of St. Louis and Lowell Ricketts is a Data Scientist at the Federal Reserve Bank of St. Louis.

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tight. By March 2022, there were 2.0 job openings for every unemployed worker. This ratio is called the vacancy to unemployment ratio, or the VU ratio, which is a common measure of labor market tightness. Before COVID, between 2015 and 2019, the VU ratio averaged 0.93.

The simultaneous decline in immigration and the 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 Brooking Institute 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 paper, we examine whether the decline in immigration during the COVID-19 pandemic is responsible for the tight labor market during the recovery. We construct measures of missing immigrant workers in the aggregate and across cities, states, and industries. We do not find support for the hypothesis that the missing immigrant workers had a significant effect on labor market tightness for two reasons. First, we find that the number of missing immigrant workers is not large enough to have had a significant aggregate impact, and the number of workers had recovered before labor market tightness increased. Second, we do not find 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 in Section 3 .1 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 US 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 trends had continued uninterrupted, minus the number of workers who were actually here.

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 immigration restrictions. Next, we compute several labor market outcomes, including labor market tightness, measured by the vacancy-to-unemployment ratio and wage growth.

Using our measures, we ask 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 positive correlation. This means that industries, states, and cities with the most missing workers did not systematically experience larger increases in the vacancy-to-unemployment 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 the immigration restrictions. In particular, this would be the case if immigrants who are unaffected by the restrictions reallocate towards tight labor markets, which would bias our estimate towards 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). Still, we do not find evidence to support the causal impact of the immigration restrictions on labor market tightness.

We note that our null result does not definitely mean that there was no impact of immigration restrictions on labor market tightness. It is possible that a researcher armed with more detailed data that allowed a more

granular level analysis would find such an effect. However, we conclude that our data does not support the hypothesis that immigration restrictions are the underlying cause of tight labor markets.

2 . EXISTING LITERATURE

This paper contributes to two strands of existing literature. First, several papers try to explain the recent increase in labor market tightness during the recovery from the COVID 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, Greogry, 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; all of these channels are likely having an impact on labor supply at the same time.

Second, this project relates to a strand of literature that has focused on the impact of COVID on immigration and its 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 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) finds that during the COVID-19 pandemic, there was a significant decline in immigration to the U.S. 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. We look into this effect at the state, industry, and city levels.

More broadly, there is extensive literature on the effect of immigration on labor markets, reviewed by Lewis and Peri (2015). There is an considerable debate in the literature 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 natives and therefore have minimal impact on their labor market outcomes.

3 . MEASUREMENT

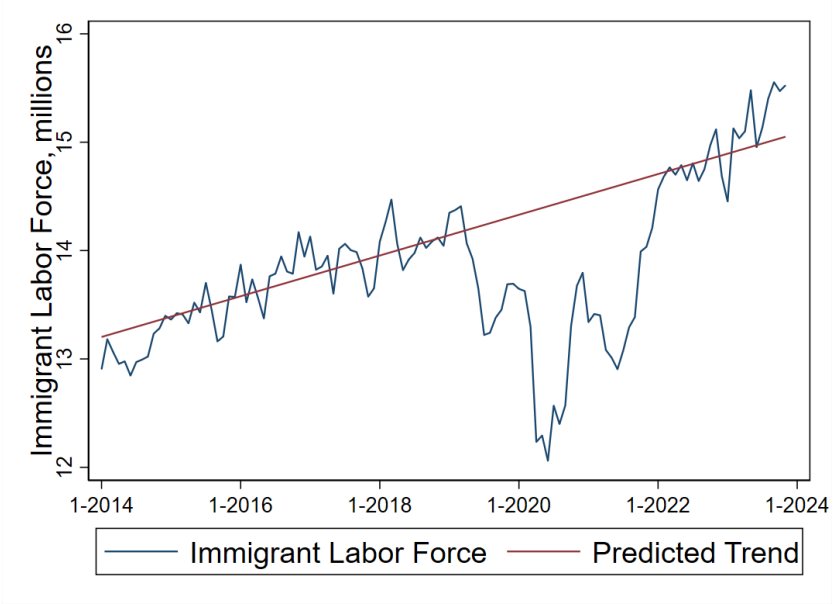
In this section, we discuss the data and methods we use to measure the number of "missing workers" and labor market tightness. Section 3 .1 discusses the data on immigration and the measure of missing workers. Section 3 .2 discusses the data on labor market outcomes.

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 immigrant workers. First, we use the CPS to look at aggregate trends. CPS offers the most up-to-date data that includes workers' citizenship status. Second, we use the one-year American Community Survey (ACS) when looking across industries, states, or cities due to its larger sample size. Unfortunately, the ACS is annual and, at the time or 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 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. Take for instance, in July 2022, we count approximately 15 million non-US 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

Figure 1 Immigrant Labor Force



SOURCE: Current Population Survey and authors' calculations.

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

Figure 1 plots the number of immigrant workers, as counted in the CPS. One can see a significant drop in 2020 during the COVID pandemic. By June 2020, the number of immigrant workers had dropped to 12.06 million. However, one can also see that it quickly recovers. The number of immigrant workers recovers to its pre-COVID peak of 14.47 million by January 2022.

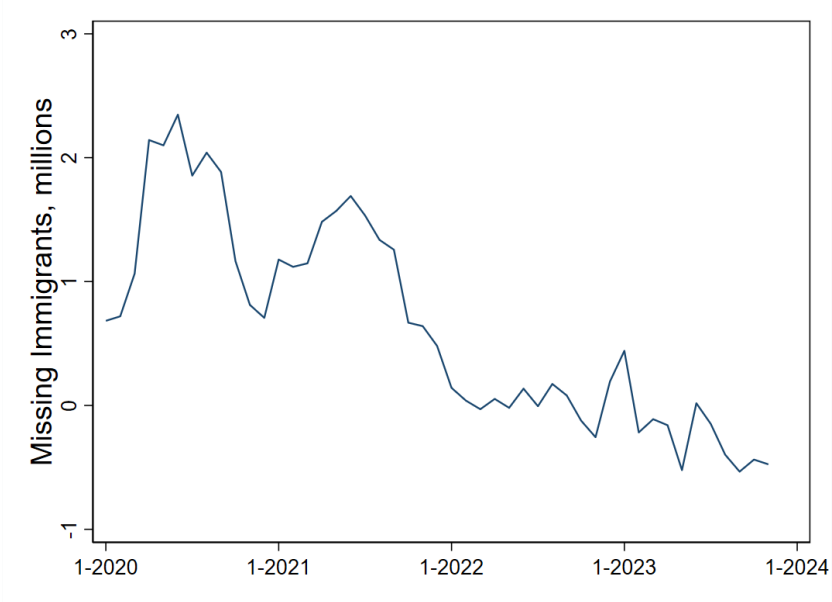
Next, we measure the number of immigrant workers that were "missing" due to the COVID pandemic. We predict how many immigrant workers there would have been based on the pre-pandemic trend (2011 to 2019), shown as the red line in Figure 1. Then, we calculate the missing immigrant workers as the difference between the predicted number and the actual number. Before the pandemic (2015-2019), there was an average of 14 million immigrant workers. From 2011 to 2019, the average growth rate of immigrant workers was 0.8% 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 immigrant workers.

Figure 2 plots the number of missing immigrant workers. The number of missing workers peaked in June 2020 at 2.35 million workers. It recovered by February 2022. In 2023, the average number of missing workers is negative, indicating that 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 in if the pre-COVID trend had continued.

Both Figures 1 and 2 show the aggregate trends. However, there is substantial heterogeneity across different segments of the economy. We look across states, cities, and industries. We measure the number of missing workers the same way as above, separately for each state, city, or industry, but we now normalize by the size of the state, city, or industry's 2019 labor force. When looking 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 percent of the 2019 labor force across states, cities, and industries. The first panel looks at missing immigrant workers by state. Unsurprisingly, states like Texas, Arizona, and Florida, which traditionally have high immigration flows, have a high share of missing immigrant

Figure 2 **Missing Immigrant Workers**



SOURCE: Current Population Survey and authors' calculations.

workers, while Idaho, Montana, and Kansas have relatively few missing immigrant workers. However, we also see that states such as Iowa and Nebraska were heavily impacted. Nevada, for example, had a labor force of about 1,475,087 people in 2019. Compared to their pre-pandemic trend they were missing 23,407 immigrant workers, meaning that about 1.59% of its pre-pandemic labor force was missing due to the immigration restrictions.

The next panel looks at missing immigrant workers by city, defined as the core-based statistical areas (CBSA). From this figure, we can see that cities like Walla Walla, WA; Key West, FL; and Ames, IA have a higher percentage of missing immigrant workers, while other cities like Wauchula, FL; Arcadia, FL; and El Centro, CA have fewer missing immigrant workers.

Finally, the third panel breaks down missing workers by industry. There is substantial heterogeneity in missing workers by industry. In some industries, such as Administration and Transportation and Warehousing, the number of immigrant workers has actually surpassed its pre-pandemic trend; as a result our estimate of the missing workers due to the COVID restrictions is negative. The mining, quarrying, and oil and gas extraction industry and the accommodation and food services industry were most impacted. They are missing upwards of 2% of their 2019 labor force.

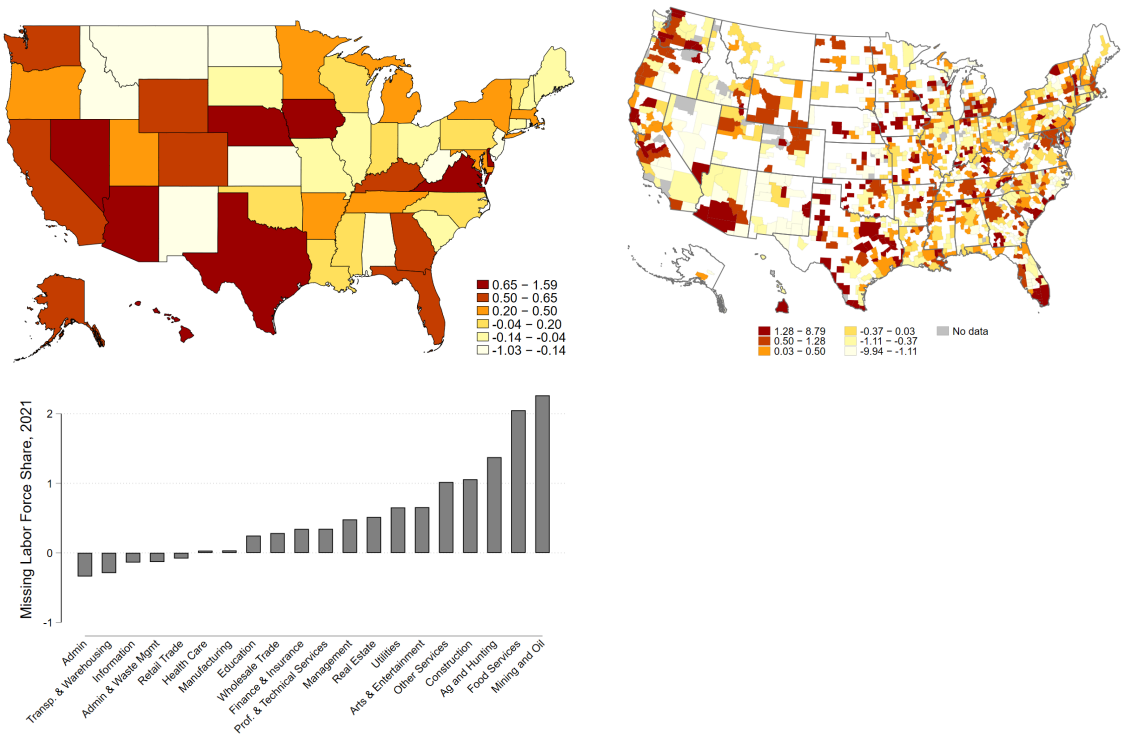
3 .2 Measuring Labor Market Outcomes

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

3 .2.1 The Vacancy-to-Unemployment Ratio

As our main measure of labor market tightness, we use the ratio of the number of vacancies to unemployed persons, known as the vacancy-to-unemployment ratio. To measure vacancies, we use data from two sources based on the level of disaggregation we are looking at. For aggregate vacancies and when looking 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 turn to a new data source for job openings by city: data from LinkUp. LinkUp is a firm that collects job listings from more than 60,000 employer websites every 24 to 48 hours. In Appendix B , we further discuss the LinkUp data, and we show the correlation of job openings in

Figure 3 **Missing Workers**



SOURCE: Job Opening and Labor Turnover Survey, Current Population Survey, and authors' calculations.

LinkUp and JOLTS across states as validation (Marks et al., 2023). To measure unemployment, we use the CPS for the aggregate series, the ACS when looking across states or industries, and the Local Area Unemployment Statistics (LAUS) when looking across cities.

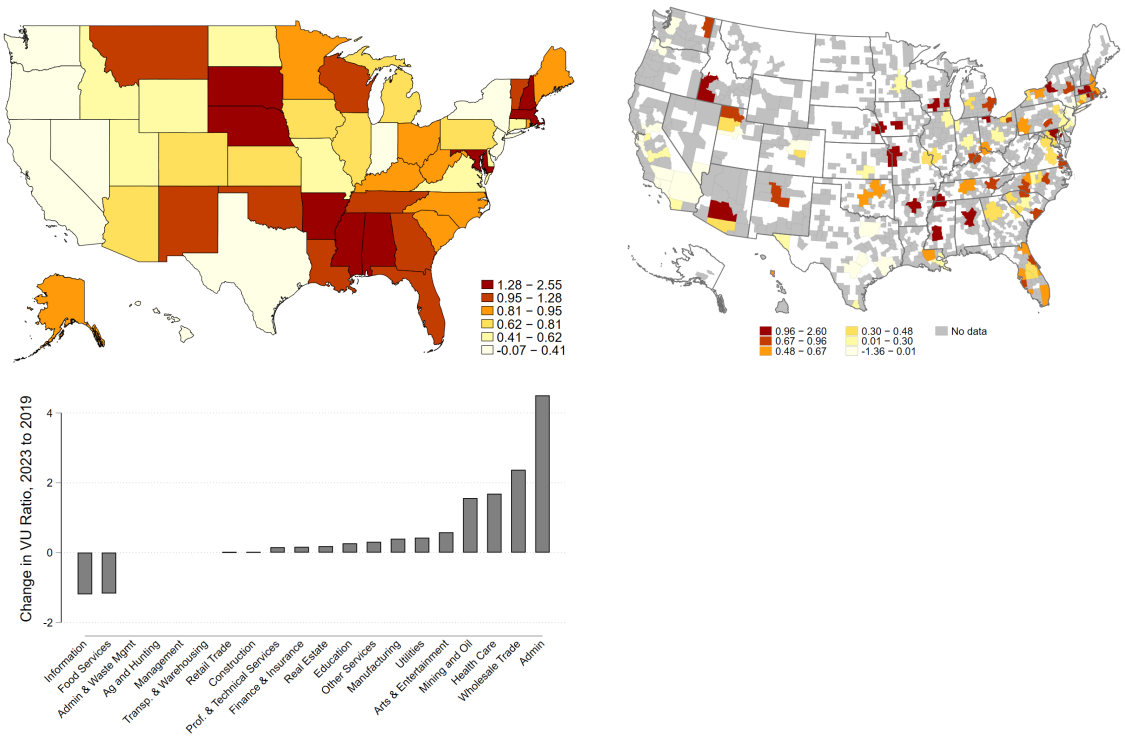
In Appendix Figure A.2, we show the level of the VU ratio in May 2023 across cities, states and industries so that one can see where the labor market is the tightest. Here we focus on where labor market tightness increased the most since 2019. To see how the vacancy-to-unemployment ratio has changed since the pandemic, we take the difference between the 2019 and 2023 Q2 VU ratios (specifically, we take the average of April, May, and June VU ratios of 2019 and 2023 for states, cities, and industries[1]). Figure 4 shows these changes. The first panel is by state, the second panel is by the top 100 most populous CBSAs, and the third panel is by industry. At the state level, South Dakota and Alabama saw the largest increase in labor market tightness. At the city level, Jackson, MS; and Omaha-Council Bluffs, NE-IA had the largest increases in labor market tightness now. By industry, wholesale trade and administration have seen the largest increase in its VU ratio.

3 .2.2 Wage Growth

Another helpful way to look at labor market tightness is through wage growth. In order to attract more workers in a tight labor market, employers may raise wages. To look at wages, we use data from the Quarterly Census of Employment and Wages (QCEW). We compute wage growth between the total quarterly wages of 2019:Q2 and 2023:Q2 for each geographic area of interest. Figure A.1 shows which cities, states and industries had the highest wage growth. These can be found in Appendix B .

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

Figure 4 **Change in VU Rate**



SOURCE: Job Opening and Labor Turnover Survey, Current Population Survey, and authors' calculations.

4 . MISSING IMMIGRANTS AND THE LABOR MARKET

In this section, we put the two previous sections together and examine the impact of the missing immigrant workers on labor markets. 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 ask whether the number of missing immigrant workers is correlated with labor market outcomes across states, cities, and industries.

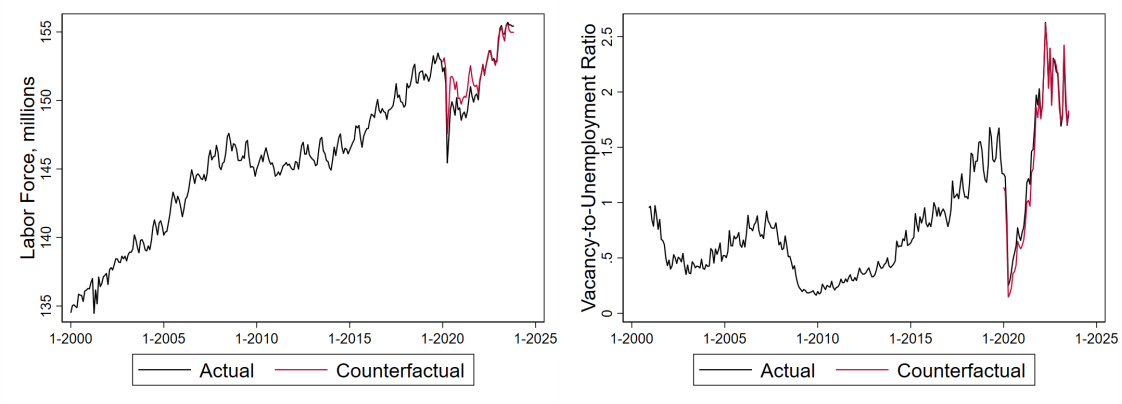
4 .1 The Aggregate Impact of Missing Workers

In this section we use our measure of missing immigrant workers to look at the aggregate impact of the 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 workers back to the labor force. The missing workers are the difference between the actual number of workers and the predicted number of workers. The effect of adding the missing workers back to the labor force is limited. We can see that the labor market would have made it back to 2019 levels in July 2021 instead of March 2022. However, recent differences between the counterfactual and the actual number of workers are small.

Figure 5 shows the aggregate impact of the missing immigrant workers on the VU ratio. We compute a counterfactual VU ratio as if immigration had continued uninterrupted. Specifically, we assume each immigrant worker would fill a single vacancy while leaving the number of unemployed workers unchanged. From this, we see that the immigrant labor force had already recovered by the time labor market tightness peaked. The biggest impact on the VU ratio happened in early 2020 when the VU ratio was still below its pre-pandemic level. By the time the labor market became tight, the level of immigration had already recovered, and both the

Figure 5 Aggregate Impact of Missing Immigrant Workers



(a) Missing Immigrant Workers: Counterfactual **(b) Vacancy-to-Unemployment Ratio: Counterfactual**

SOURCE: Current Population Survey and authors' calculations.

actual and the counterfactual show similar VU ratios. This suggests that the missing immigrant workers did not drive labor market tightness.

4.2 Missing Immigrants Across Labor Markets

Next, we look at the impact of the immigration restrictions on specific labor markets. We ask whether the states, cities, and industries that were most impacted by immigration restrictions also had the biggest increases in labor market tightness, measured using the vacancy-to-unemployment ratio and wage growth.

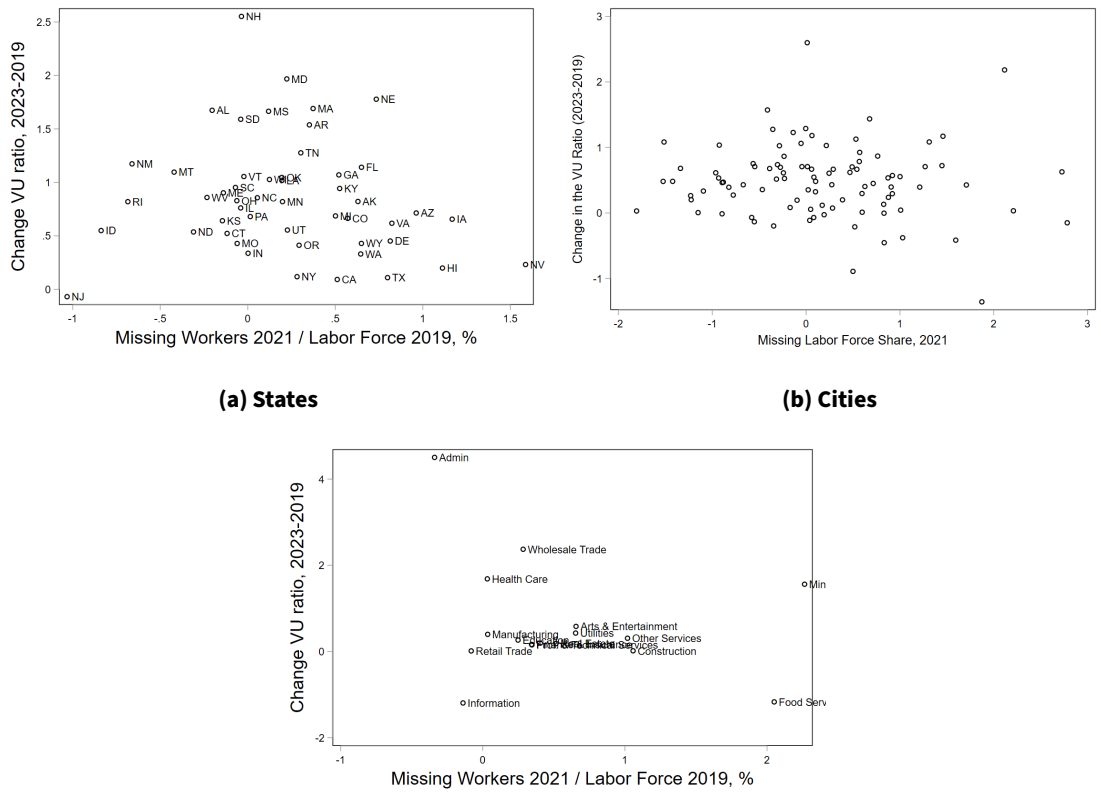
As previously mentioned, although correlations between the vacancy-to-unemployment ratio and missing immigrant workers would be suggestive of a causal relationship, it is not enough to state that the missing immigrant workers have a causal effect on labor market tightness. Thus, in the next section, we use an instrumental variable approach to examine the causal impact of immigration restrictions on the labor market.

Figure 6 plots the correlation between the 2019 to 2023 change in the vacancy-to-unemployment rate and the 2021 share of missing immigrant workers from the 2019 labor force. The first panel shows this correlation by state, the second by city, and the third panel 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, and states such as Nevada and Iowa, are not the same markets that had the largest increase in the VU ratio–sectors such as Administration and Wholesale trade and states like New Hampshire and Maryland.

Next, we look at our second measure of labor market tightness: wage growth. Figure 7 plots the correlation between wage growth and the share of missing immigrant workers from the 2021 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.

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. However, these correlations could be obscuring the true causal impact of immigration on labor market tightness. To address this, we next turn our attention to a causal analysis.

Figure 6 **Correlation between Change in VU Ratio and Missing Immigrant Workers**



(a) States **(b) Cities**

(c) Industries

SOURCE: Job Opening and Labor Turnover Survey, Current Population Survey, and authors' calculations.

5 . CAUSAL ANALYSIS

The previous correlations are not causal. There are a number of reasons that the correlations could obscure the true impact of immigration on the labor market. For example, if the immigrants who are able to remain in the U.S. move towards the tightest labor markets, then it will appear as if these labor markets have not been affected by the restrictions.

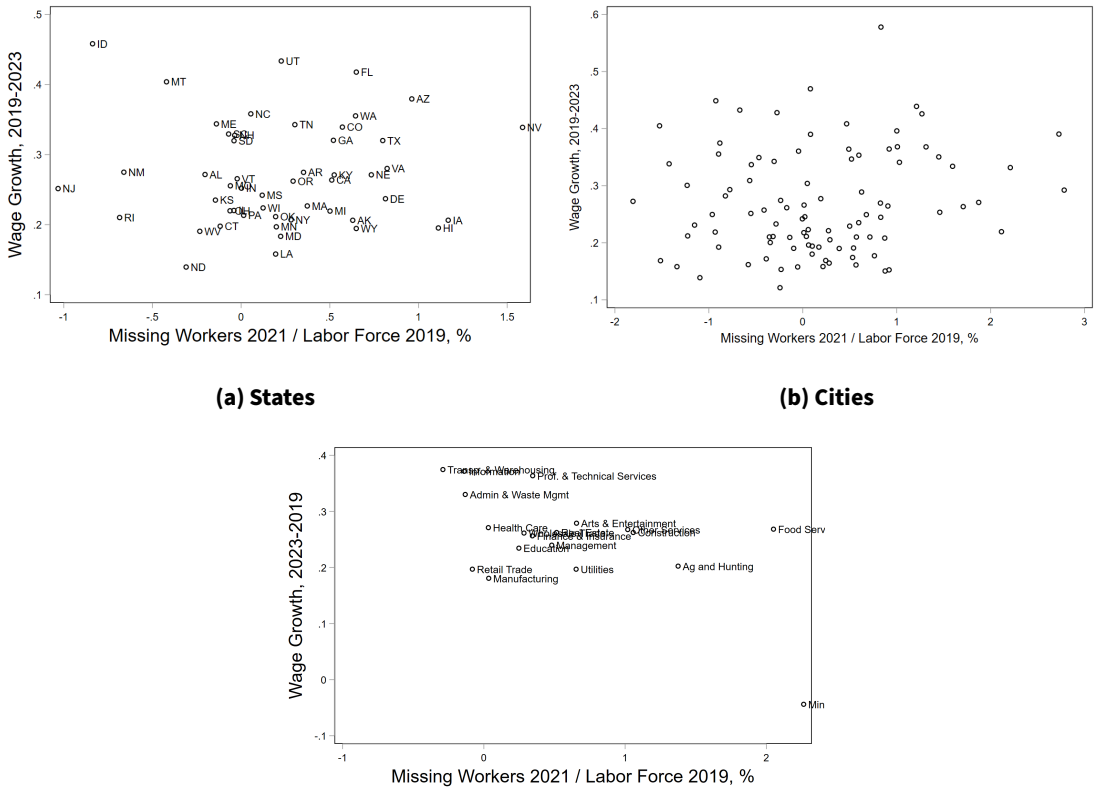
In this section, we develop a shift-share instrument to examine the causal impact of the immigration restrictions on local labor market tightness. Our instrument builds on the work of Peri and Zaiour (2023) and Card (2009) who both use shift-share instruments based on immigrant country-of-origin.

We start by grouping immigrants into 51 groups by country-of-orgin. We use the 50 countries with the largest immigration flows and group the remaining countries into the 51st other category. Then, for each country of origin o, we calculate the number of missing workers as we describe 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 the missing immigrants from country o as the predicted number of immigrants minus the actual immigrants, $X_{ot} = \hat{I}_{ot} - I_{ot}$. We interact this with the share of immigrants from country o who live in state or city g in 2010, $S_{o,g,2010}$ to create the shift-share instrument:

$$F_{gt} = \frac{\sum_o S_{o,g,2010} X_{o,t}}{Pop_{g,2010}},$$

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

Figure 7 **Correlation between Change in Wage Growth and Missing Immigrant Workers**



SOURCE: Job Opening and Labor Turnover Survey, Current Population Survey, and authors' calculations.

immigrants from country o who lived in state or city g in 2010. Finally, we normalize by the population of the state or city 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. First, the instrument would be valid if the initial immigrant shares were uncorrelated with the changes in labor market tightness that we are interested in measuring (Goldsmith-Pinkham, Sorkin, and Swift, 2020). This assumption is unlikely to hold as immigrants often work in certain industries that are geographically concentrated (such as agriculture), and these industries may have been more or less affected by the pandemic. However, even if this first assumption does not hold, the instrument would be valid if the initial shares are uncorrelated with the national immigration shocks (Borusyak, Hull, and Jaravel, 2022). Because the immigration shocks were driven by the response to the plausibly exogenous COVID shock, we believe this second assumption is likely to hold. The assumption is that the immigration shock affected immigrants from various countries of origin differently and that these differences are uncorrelated with local country-of-origin immigration shares. For example, one of the first immigration acts was a suspension of entry of all immigrants from China, motivated by fear of the disease rather than motivated by the potential labor market impacts (Trump, 2020a).

We run two instrumental variables (IV) regressions, examining the impact of the 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. The second column shows the causal effect of the missing immigrants on the change in VU ratio between 2019 and 2023. A 1 percentage point larger share of the labor force that is missing causes a change in the VU ratio that is about 0.8 percentage points smaller. In other words, the coefficient is the opposite of what you would expect 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 were systematically different in their industry composition. For example, the COVID shock might have erased relatively more vacancies in cities that were concentrated in the service sector which in turn might have traditionally been 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 the 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 had larger wage growth. This is what one would expect if the missing workers had caused an increase in labor market tightness, putting upward pressure on wages. Specifically, a 1 percentage point larger share of the labor force that is missing causes a 0.05 percentage point larger increase in average wage growth.

6. CONCLUSION

In this paper, we looked at how immigration has affected 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.

We conclude this for two reasons. First, the aggregate data tells us that the number of immigrant workers has returned to pre-pandemic levels. Plotting a simple counterfactual shows us that both the level and vacancy-to-unemployment ratio have largely recovered from pandemic immigration restrictions. 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, looking across states and cities, we ask if missing immigrant workers had a significant impact on labor market tightness. Overall, 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.

Understanding that correlations could obscure the true effect of missing immigrant workers, we use a shift-share instrument to further investigate the potential relationship between a decline in immigration and labor market tightness. We run two instrumental variable 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 was the driver for 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 that preclude an analysis at finer levels of disaggregation. Further research, perhaps with more detailed data, may find an impact, particularly in certain labor markets and industries.

Table 1 IV Regressions

	Panel A: States		
	(1)	(2)	(3)
	first	second	second
VARIABLES	Missing LF Share (2021)	Ch. in VU Ratio (2019-2023)	Wage gr. (2019-2023)
Instrument Missing Workers (2021)	1.861***		
	(0.453)		
Missing LF Share (2021)		-0.755**	0.0612
		(0.331)	(0.0429)
Constant	-0.0598	1.023***	0.257***
	(0.0932)	(0.113)	(0.0146)
Observations	50	50	50
R-squared	0.260		
IV F-stat	16.85		
Durbin pval	0.0122		

	Panel B: Cities		
	(1)	(2)	(3)
	first	second	second
VARIABLES	Missing LF Share (2021)	Ch. in VU Ratio (2019-2023)	Wage gr. (2019-2023)
Instrument Missing Workers (2021)	1.710***		
	(0.387)		
Missing LF Share (2021)		-0.734***	0.0524**
		(0.225)	(0.0257)
Constant	-0.191	0.607***	0.261***
	(0.118)	(0.0934)	(0.0107)
Observations	96	96	96
R-squared	0.172		
IV F-stat	19.52		
Durbin pval	3.40e-07		

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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

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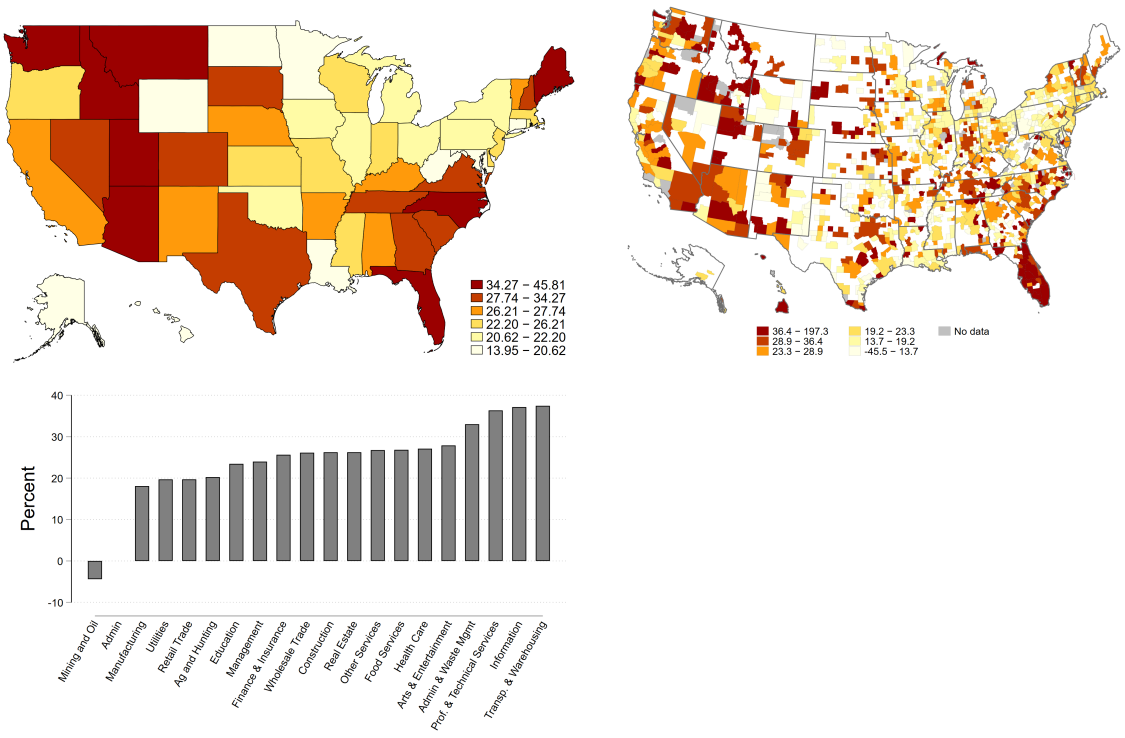
Figure A.1 **Wage Growth 2019-2023**



SOURCE: Job Opening and Labor Turnover Survey, Current Population Survey, and authors' calculations.

A . ADDITIONAL DATA FIGURES

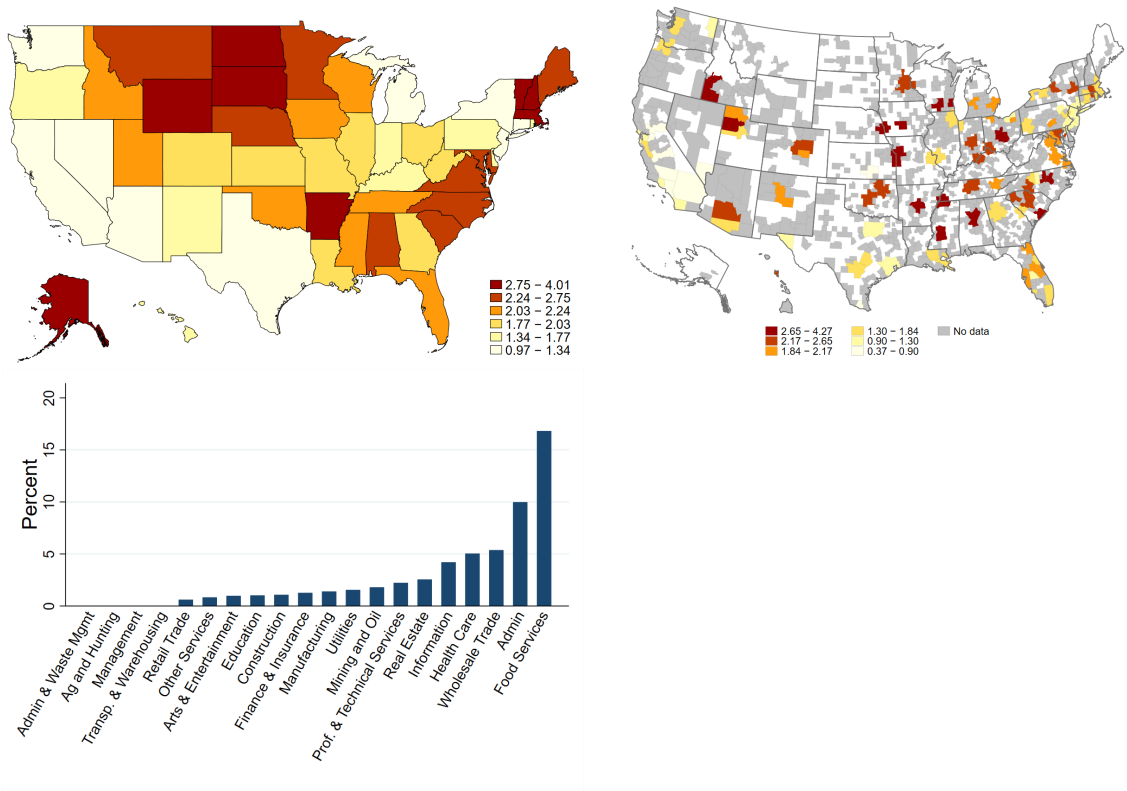
In this section, we include several additional figures that we could not include in the main text. First, in Figure A.1, we show wage growth across states, cities, and industries. States with the highest wage growth include Idaho, Utah, and Florida. The sectors with the highest wage growth were Transportation and Warehousing and Information.

In the main text, in Figure 4, we show 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. Accommodation and Food Services and Administration are the tightest sectors.

B . COMPARING JOLTS AND LINKUP DATA

To measure vacancies at the city level, 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 information from employer websites. They collect their data directly from more than 60,000 employer websites by scraping 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 suggest that the job isn't 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.

Figure A.2 **May 2023 Vacancy-to-Unemployment Ratio**



SOURCE: Job Opening and Labor Turnover Survey, Current Population Survey, and authors' calculations.

For example, 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.

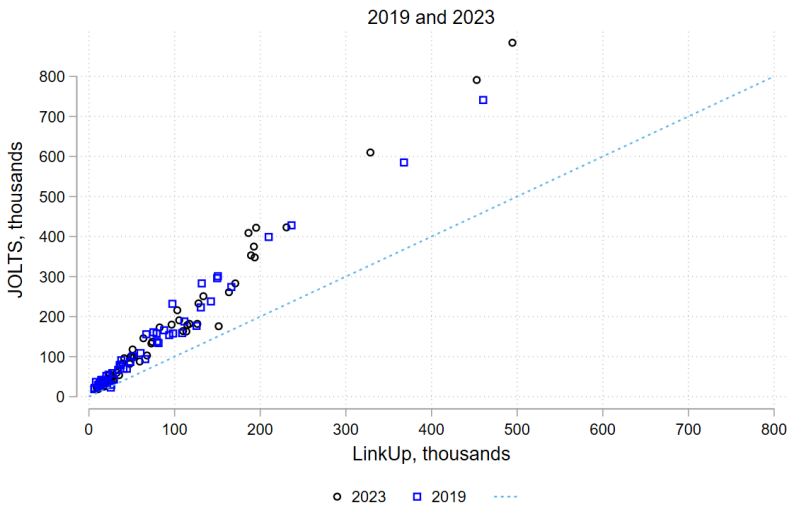
While this dataset is powerful, there are some potential caveats. One concern is that increases in overall job listings might not be caused by actual job creation, rather it could be driven by increasing coverage of the employer universe via LinkUp's continued expansion of web scraping efforts. However, LinkUp's sample of employers is primarily composed of (although not limited to) employers included in major financial indexes (e.g., S&P 500, Russell 1000). Given that they have achieved close to 100% coverage of employers represented in these major financial indexes, the sample is relatively stable and captures job listings for the largest corporate 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 they are 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.3 shows the job openings in JOLTS compared to job listings in the LinkUp data. The correlation between the JOLTS and LinkUp data is 0.99 for May 2019 and 2023. This suggests that the LinkUp data is capturing variation in the number of job listings across states, not variation in the popularity of the company based on region. This gives us confidence that when we use the LinkUp data to measure job listings at the city level, it will capture true local variation in job listings.

Notably, the LinkUp data does not capture all the job openings seen in JOLTS. The dashed line indicates a 45-degree line. If the LinkUp data and JOLTS data were the same, all points would lie along the 45-degree line. Though the LinkUp data is highly correlated with JOLTS, the level of job listings is different. The points

Figure A.3 Correlation between JOLTS and LinkUp Job Openings



SOURCE: Job Opening and Labor Turnover Survey and LinkUp Data.

lie above the 45-degree line indicating that the LinkUp data is missing vacancies that are in JOLTS. Across all states, the LinkUp data is missing an average of 46% of the vacancies in JOLTS. This means that in levels, the LinkUp data is missing more job listings in larger states than in smaller states because 46% of a large number is larger. Thus, we scale the vacancies in each state or city by the state-level error in 2019, where the state level error is defined as the percent of the state's JOLTS job openings that are missing in the LinkUp data.