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# Inclusive Monetary Policy: How Tight Labor Markets Facilitate Broad-Based Employment Growth

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June 2023

### Abstract

This paper analyzes the heterogeneous effects of monetary policy on workers with differing levels of labor force attachment. Exploiting variation in labor market tightness across metropolitan areas, we show that the employment of populations with lower labor force attachment—Blacks, high school dropouts, and women—is more responsive to expansionary monetary policy in tighter labor markets. The effect builds up over time and is long lasting. We develop a New Keynesian model with heterogeneous workers that rationalizes these results. The model shows that expansionary monetary shocks lead to larger increases in the employment of less attached workers when the central bank follows an average inflation targeting rule and when the Phillips curve is flatter. These findings suggest that, by tightening labor markets, the Federal Reserve's recent move from a strict to an average inflation targeting framework especially benefits workers with lower labor force attachment.

**JEL classification: E12, E24, E31, E43, E52, E58, J24**

**Keywords: Monetary Policy, Labor Markets, Heterogeneous Agents, Federal Reserve**

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*With regard to the employment side of our mandate, our revised statement emphasizes that maximum employment is a broad-based and inclusive goal. This change reflects our appreciation for the benefits of a strong labor market, particularly for many in low- and moderate-income communities.*

Jerome Powell, 2020 Jackson Hole Economic Policy Symposium

# I  Introduction

Following its 2020 Monetary Policy Review, the Federal Reserve emphasized maximum employment as a "broad-based and inclusive goal" and stressed the importance of "understanding how various communities are experiencing the labor market when assessing the degree to which employment in the economy as a whole is falling short of its maximum level" (Federal Reserve 2020). At the Jackson Hole Economic Policy Symposium, Chairman Powell (2020) underscored the need to sustain a strong labor market to generate employment gains more widely across society. Despite this new focus, monetary policy's heterogeneous effects on different segments of the labor markets are not well understood. In this paper, we study how labor market strength intermediates the effect of monetary policy across different types of workers and demographic groups.

Our empirical analysis explores monetary policy's heterogeneous effects with respect to workers' race, education, and sex. We investigate how expansionary monetary policy promotes employment growth for each group across local labor markets with different tightness. We find that for demographic groups with lower average labor market attachment—Blacks, the least educated, and women—expansionary monetary policy has a larger effect on employment growth in tighter labor markets. Because expansionary monetary policy tightens labor markets (Coibion et al. (2017)), this finding implies that sustaining expansionary monetary policy over longer time periods is particularly helpful to these demographic groups.

For each demographic group, we regress employment growth on the interaction between the federal funds rate and local labor market tightness, measured across 895 local labor markets in the US between 1990 and 2019. The local market panel nature of our data allows us to include industry-by-quarter fixed effects, which absorb aggregate demand for a given industry's output and other unobserved, industry-level, temporal variation in employment growth common across locations.[1] All regressions also include industry-by-location fixed effects to control for time invariant, location-specific variation in employment growth common

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[1]The uninteracted effect of monetary policy on employment growth is not identified in the presence of these

to a given industry (driven, for example by variation in the local supply of human capital or the quality of transportation systems). For a given demographic group, our analysis is identified by comparing how monetary policy affects that group's employment growth in tight as compared to slack labor markets.

Our results show that for demographic groups with low average labor market attachment—Blacks, the least educated, and women—monetary expansions have a larger effect on employment growth in tight labor markets, which we measure using the market's aggregate prime-age employment-to-population ratio. This effect is economically large. For example, we find that a one standard deviation drop in the federal funds rate increases subsequent two-year Black employment growth by 0.91 percentage points more in tight labor markets (90th percentile) than in slack labor markets (10th percentile). Similarly, for workers who did not complete high school, a one standard deviation drop in the federal funds rate increases employment growth over the subsequent two years by 0.39 percentage points more in tight labor markets than in slack ones. This additional impact of monetary policy in tight labor markets is sizable, corresponding to 9% and 18% of the mean employment growth rates for Blacks and high school non-completers over the sample period, respectively.

Whereas labor market tightness plays an important role in mediating the effect of monetary policy on employment for demographic groups with lower labor market attachment, this effect is muted or non-existent for groups with stronger labor market attachment. For example, the point estimate for White employment growth is less than one quarter of the estimate for Blacks and not statistically significant. All of the differences in the effect of monetary policy—between Blacks and Whites, between less and more educated, and between women and men—are statistically significant.

The effects on less-attached workers are persistent. We find that monetary policy's incremental effect on less-attached workers' employment growth in tight labor markets peaks 7 to 9 quarters after interest rates decreases. Although monetary policy's incremental effect wanes over time, its cumulative effect is long lasting. For example, the differential effect of monetary policy on cumulative Black employment growth in tight versus slack labor markets persists even four years after the federal funds rate decreases.

To alleviate remaining concerns about the endogeneity of monetary policy after absorbing aggregate conditions including inflation and the output gap through fixed effects, we confirm that the results are robust to estimating an instrumental variables two-stage least

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time fixed effects, but the differential effect of monetary policy in tight as compared to slack labor markets is identified.

squares (2SLS) regression framework which, following Kuttner (2001), Wong (2016), and Gorodnichenko and Weber (2016), exploits high frequency innovations in the federal funds futures rate around Federal Open Market Committee (FOMC) announcements. We use the running sum of these innovations to instrument for the federal funds rate itself. This instrumental variable estimation is in the spirit of Gertler and Karadi (2015), who use high frequency monetary shocks as an external instrument within a structural VAR framework. We confirm both quantitatively and statistically our baseline findings.

We then present a simple New Keynesian model with heterogeneous workers to analyze how monetary policy affects different parts of the labor market. In the model, worker types are differentiated by their productivity level. We do not model the sources of the variation in productivity, which could include differences in education levels, labor market experience, worker-firm match quality, on-the-job discrimination, workplace harassment, or other factors. In each period, firms retain and hire workers with productivity above endogenous thresholds. Monetary policy affects these thresholds.

We show that expansionary monetary policy lowers the hiring and firing thresholds, resulting in greater employment, particularly among lower productivity workers. Further, the expansionary effect of monetary policy on the employment of lower productivity workers is stronger in tighter labor markets. This comparative static, which directly supports our empirical estimates, is driven by two forces. First, in tighter labor markets, marginal workers have lower productivity. Second, in tighter labor markets, employment expands more easily because screening for lower productivity workers is less costly. Higher productivity workers also benefit from monetary expansions, but less so, and their employment is less sensitive to labor market tightness.

The analysis highlights the benefit of sustained expansionary monetary policy for workers with lower labor force attachment, which the central bank trades off against inflationary pressure. The Federal Reserve's 2020 Monetary Policy review, which shifted policy from strict to average inflation targeting, enables the central bank to maintain lower rates during economic expansions. Following Svensson (2020), we model this new policy by replacing the current inflation rate in the central bank's Taylor rule with the average inflation rate over the current and eleven previous quarters. We show that average inflation targeting results in larger declines in the hiring threshold and larger increases in employment. Lower productivity workers especially benefit from the average inflation targeting policy, with larger increases in employment as compared to higher productivity workers.

The flattening of the Philips curve over the past decades before the Covid-19 pandemic

reduces inflationary pressure from tight labor markets, altering the tradeoff between output and inflation (see, e.g., Simon et al. (2013) and Hall (2013)). We study this phenomenon in the model by varying the degree of price stickiness in the economy. When price stickiness is higher and thus the Philips curve is flatter, the central bank retains lower rates over a longer period, enabling greater labor force participation of lower productivity workers over time.

Taken together, our theoretical and empirical results both point to the importance of labor market tightness in mediating the impact of monetary policy on workers with low labor force attachment. Monetary expansions boost the employment of these workers the most when labor markets are tight, with the effect on employment building up over time and lasting for years. The results thus suggest that the Federal Reserve's recent change in monetary policy regime, from strict to average inflation targeting, will benefit segments of the labor force that have lower historical employment rates. Optimal policy should consider this benefit of prolonging monetary expansions alongside costs arising from the associated inflationary pressure.

Our paper is the first to study the role of labor market tightness in transmitting monetary shocks differentially into employment growth. We build on prior work that uses aggregate data to study the effect of monetary policy on wealth and consumption inequality (see, e.g., Romer and Romer (1999), Zavodny and Zha (2000), Thorbecke (2001), Carpenter and Rodgers III (2004), Coibion et al. (2017)). In contemporaneous research, Amberg et al. (2021) and Peydró et al. (2021) use annual registry data from Sweden and Denmark to study the effect of monetary policy on consumption and wealth inequality. Coglianese et al. (2021) use the unexpected interest hike in Sweden in 2010-2011 to show that workers with shorter tenure were more negatively affected than other workers. Moser et al. (2021) use the introduction of negative policy rates in Europe as a negative credit supply shock, resulting in lower wages in Germany. Based on aggregate data, Bartscher et al. (2021) find that expansionary monetary policy increases the employment of black households slightly more than that of white households. We differ from these papers in that we study the role of labor market tightness as a mediating factor for the employment response of workers with lower average labor market attachment, showing that monetary policy's ability to reduce employment inequality depends crucially on labor market tightness.

Our theoretical analysis builds on Blanchard and Diamond (1994) and Blanchard (1995), which describe so-called "ranking" effects in labor markets, and the vast New Keynesian literature studying the real effects of monetary policy. Early contributions adding labor markets into the New Keynesian model focus on the size and the persistence of the effects of monetary

policy shocks (Walsh (2003), Walsh (2005), Trigari (2009)). A recent strand of the literature adds various labor market frictions to the baseline model to study normative questions such as how unemployment affects the design of optimal monetary policy.[2] These models do not, however, deal with the heterogeneous effects of monetary policy across worker types. Our model is closest to Ravenna and Walsh (2012), who model two types of workers competing for identical jobs with firms screening workers to determine their productivity. Ravenna and Walsh (2012) focus on understanding how productivity shocks affect the unemployment-inflation tradeoff through a composition effect of the unemployed, whereas we study the effect of exogenous monetary policy on different parts of the productivity distribution. Ravenna and Walsh (2021) extend their model to study the selection effect of the Covid-19 pandemic. Our analysis is also related to Baek (2020) who extends Christiano et al. (2020) and derives optimal monetary policy in a New Keynesian model with regular and irregular workers without perfect consumption insurance.

While we focus on labor market tightness and workers' attachment, monetary policy also has heterogeneous effects through other channels. The recent and growing Heterogeneous Agent New Keynesian (HANK) literature analyzes the role of households' financial portfolio liquidity in propagating monetary policy shocks (see, e.g., Auclert (2019), Kaplan et al. (2018), Auclert et al. (2020), Bayer et al. (2019), Krueger et al. (2016)). Research also shows that monetary policy is mediated by home equity (Beraja et al. (2019), Wong (2016)) and the historical path of interest rates (Berger et al. (2018) and Eichenbaum et al. (2018)).

The remainder of the paper is organized as follows. Section II describes the data and empirical analysis. The model setup is presented in Section III and simulation results in Section IV. Section V concludes.

## II  The Heterogeneous Effects of Monetary Policy on Employment Growth

In this section we show that monetary policy has heterogeneous effects on employment across different demographic groups, which have varying degrees of labor market attachment. Exploiting cross-sectional variation in labor markets, we examine how local labor market tightness mediates the effect of monetary policy on employment for different demographic groups.

Our empirical design, which exploits the data's panel structure, has a number of ad-

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[2]See, e.g, Blanchard and Galí (2010); Faia (2008, 2009)); Gertler et al. (2008); Christiano et al. (2010); Christiano et al. (2011); Galí (2011a); Galí (2011b); and Galí et al. (2012).

vantages. First, given the endogenous nature of monetary policy, controlling for time-series variation in national economic conditions is crucial. This is not possible using national level data. Second, with panel data we can control for time invariant, location-specific factors which can affect the relation between monetary policy and employment growth. Finally, using cross-sectional data on local labor markets provides a larger range of observed labor market tightness which increases the power of our tests.

We document a novel set of facts: employment growth of Blacks, less educated workers, and women is more sensitive to monetary policy in tighter labor markets. For these groups, which are less attached to the labor market, monetary policy expansions are associated with larger increases in employment growth when labor markets are tight as opposed to when they are slack. These effects build over time and last several years. In contrast, for Whites, more educated workers, and men, the responsiveness of employment growth to monetary policy is less sensitive to the degree of labor market tightness.

## *A.* **Data**

Our main data source is the United States Census Bureau's Quarterly Workforce Indicators (QWI) program. From QWI, we obtain quarterly local labor market level employment statistics for industry-worker demographics cells. These data, which cover the period Q1 1990 to Q1 2019, are ultimately sourced from a variety of administrative records, including state unemployment insurance systems, the Social Security Administration, and the Internal Revenue Service. The sample includes 895 local labor markets: 380 Metropolitan Statistical Areas and 515 Micropolitan Statistical Areas. For ease of exposition, we refer to these areas using the terms MSA-level and local-level interchangeably, although our analysis includes Micropolitan Statistical Areas as well.

Our analysis focuses on heterogeneity in employment growth within three demographic categories: race, education, and sex. Table 1 lists the groups that we analyze within each category along with their mean employment rate over the sample period. Labor force attachment varies considerably across the demographic groups. The average employment rate is lower for Blacks than for Whites (56.6% and 62.3%), lower for women than for men (55.2% and 68.5%), and increases monotonically with education. All of these differences are highly statistically significant.

For each quarter $t$, we observe the number of individuals belonging to a given demographic group employed in the MSA in a given 2-digit NAICS industry. For each demographic group, MSA, and industry cell, we calculate the employment growth over the subsequent two

years, from the beginning of quarter $t + 1$ through the end of quarter $t + 8$. We analyze employment growth over different horizons, from one to 16 quarters. To be included in the sample, we require an MSA-industry-group-quarter cell to have at least 50 employees. Employment growth is winsorized at its 1% tails.

We measure local labor market tightness using the prime-age employment-to-population ratio. The numerator in this ratio is the number of employees aged 25-54 in the MSA, obtained from QWI.[3] The denominator is the population of MSA residents aged 25-54, obtained from the U.S. Census Bureau Population Estimates Program. Although data on vacancies are not available at the MSA level over our sample period, our measure of labor market tightness is highly correlated with vacancy-to-unemployment ratios at the national level. For example, over the period 1990q1–2019q1, the correlation between prime-age employment to population and the ratio of the Barnichon vacancy index to the number of unemployed workers is 0.66. Following an HP filtering of the two series, the correlation is 0.9.

Our analysis includes two measures of monetary policy: the federal funds rate and the history of unexpected high-frequency innovations in the federal funds futures. Data on the effective federal funds rate are from Federal Reserve Economic Data (FRED) at the Federal Reserve Bank of St. Louis. We calculate the average rate over a quarter using the four monthly federal funds rates spanning the quarter (i.e., the rates at the beginning of each month and the rate at the end of the quarter). Our data on high frequency innovations in the federal funds futures market around FOMC meetings follows Kuttner (2001), Wong (2016), and Gorodnichenko and Weber (2016).

Let $ff_{t,0}$ denote the rate implied by the current-month federal funds futures on date $t$ and assume that one FOMC meeting takes place during that month. $t$ is the day of the FOMC meeting and $D$ is the number of days in the month. We can then write $ff_{t,0}$ as a weighted average of the prevailing federal funds target rate, $r_0$, and the expectation of the target rate after the meeting, $r_1$:

$$ff_{t,0} = \frac{t}{D} r_0 + \frac{D - t}{D} \mathbb{E}_t(r_1) + \mu_{t,0}, \tag{1}$$

where $\mu_{t,0}$ is a risk premium.[4] Gürkaynak et al. (2007) estimate risk premia of 1 to 3 basis points, and Piazzesi and Swanson (2008) show that they only vary at business-cycle frequen-

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[3]Because the QWI does not include federal employees, we exclude the District of Columbia from the sample, but this exclusion does not meaningfully affect our results.

[4]We implicitly assume date $t$ is after the previous FOMC meeting. Meetings are typically around six to eight weeks apart.

cies. We focus on intraday changes to calculate monetary policy surprises and neglect risk premia, as is common in the literature.

We can calculate the surprise component of the announced change in the federal funds rate, $v_t$, as:

$$v_t = \frac{D}{D-t}(ff_{t+\Delta t^+,0} - ff_{t-\Delta t^-,0}), \tag{2}$$

where $t$ is the time when the FOMC issues an announcement, $ff_{t+\Delta t^+,0}$ is the fed funds futures rate 20 minutes after $t$, $ff_{t-\Delta t^-,0}$ is the fed funds futures rate 10 minutes before $t$, and $D$ is the number of days in the month.[5] The $D/(D-t)$ term adjusts for the fact the federal funds futures settle on the average effective overnight federal funds rate.

When the event day occurs within the last seven days of the month we follow Gürkaynak et al. (2005) and use the unscaled change in the next-month futures contract. This approach ensures small targeting errors in the federal funds rate by the trading desk at the New York Fed, revisions in expectations of future targeting errors, changes in bid-ask spreads, or other noise, which have only a small effect on the current-month average, are not amplified through multiplication by a large scaling factor. Following convention, we call monetary policy surprises expansionary when the new target rate is lower than predicted by fed funds futures before the FOMC meeting, that is, when $v_t$ is negative; and we call positive $v_t$ contractionary.

In a robustness test, we instrument for the federal funds rate using the running sum of these high frequency monetary policy innovations. Whereas each innovation captures a change in the Federal Funds rate, their running sum is akin to the level of the Federal Funds rate. For each quarter $t$, we sum the innovations that occurred from the start of the sample period through $t$.

Table 2 shows summary statistics for various variables of interest. The average federal funds rate in the sample is 2.32%, while the average employment-to population-ratio is 0.67. The average two-year employment growth rate is 10.0% for Blacks and 6.1% for Whites. Employment growth is also more volatile for Blacks than for Whites (standard deviation of 21.8% as compared to 13.7%), which is consistent with Black employment growth being more cyclical.

The average employment growth rate also varies with workers' education and sex. The

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[5]We implicitly assume in these calculations that the average effective rate within the month is equal to the federal funds target rate and that only one rate change occurs within the month.

average two-year employment growth rate is twice as high for workers without a high school degree (2.1%) as for those with a bachelor's degree (1.1%).[6] Average growth rates are more similar for men (7.0%) and women (6.5%).

## *B.* **Results**

For each demographic group $g$, we run the following OLS regression relating the growth rate of employment to the federal funds rate and local labor market tightness:

$$EmplGrowth_{j,g,m,t} = \beta_1 \times FedFunds_t \times Empl/Pop_{m,t-1} +$$
$$\beta_2 \times Empl/Pop_{m,t-1} + \theta_{j,m} + \delta_{j,t} + \epsilon_{j,g,m,t}, \quad (3)$$

where $EmplGrowth_{j,g,m,t}$ is the growth rate of employment for demographic group $g$ from the beginning of quarter $t+1$ through the end of quarter $t+8$ in industry $j$ and local labor market $m$; $FedFunds_t$ is the average federal funds rate during quarter $t$; and $Empl/Pop_{m,t-1}$ is the prime age employment-to-population ratio in labor market $m$ at the beginning of quarter $t$. Industry-by-MSA fixed effects, $\theta_{j,m}$, absorb unobserved, time invariant, location-specific variation in employment growth that is common to a given industry. These fixed effects control for variation in employment growth that is driven by, for example, the local supply of human capital, regulatory environments and legal infrastructure conducive to growth, and transportation systems. Industry-by-quarter fixed effects, $\delta_{j,t}$, absorb unobserved, industry-level, temporal variation in employment growth that is common across locations, including, for example, variation in the aggregate demand for a given industry's products. Throughout the analysis, the standard errors are adjusted for clustering at the local labor market level.

   Although the industry-by-quarter fixed effects prevent us from identifying the main effect of monetary policy on employment growth, the MSA-panel nature of our dataset, which includes local labor markets with varying degrees of labor market tightness, enables us to identify the relation between employment growth and the interaction of monetary policy and labor market tightness. For each demographic group, the coefficient of interest, $\beta_1$, captures how the sensitivity of employment growth to the federal funds rate varies with labor market tightness, measured using the employment-to-population ratio. This coefficient is identified by comparing how employment growth for a given industry and locality responds differen-

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[6]In the QWI, education categories are defined for workers aged 25 and older, who have lower average employment growth rates than younger workers.

tially to variation in monetary policy in tight, as compared to slack labor markets.[7]

Table 3 presents OLS estimates of equation (3). Each column in Table 3 examines the employment growth of a different demographic group. Panel A of the table examines heterogeneity with respect to workers' race, presenting results for Blacks in column 1 and Whites in column 2. For Blacks, the coefficient on the interaction between the federal funds rate and local labor market tightness, $\beta_1$, is negative, sizable, and statistically significant. This coefficient implies that a monetary easing is associated with greater Black employment growth in tight labor markets as compared to in slack ones. To assess the magnitude of this estimate, consider the effect of a one standard deviation (2.25 percentage point) decrease in the federal funds rate. Our estimate implies that, over the subsequent two years, this drop in the federal funds rate is associated with a 0.91 percentage point larger increase in Black employment growth in labor markets at the 90th percentile of employment-to-population (86%) than in labor markets at the 10th percentile of employment-to-population (49%). This additional boost in employment growth in tighter labor markets is sizable, corresponding to 9% of the mean two-year Black employment growth over the sample period.

To illustrate the heterogeneity in monetary policy's effect across labor markets implied by our estimates of equation (3), Figure 1 plots, for a given point in time, predicted black employment growth across labor markets with different degrees of tightness. Specifically, the figure plots the predicted differential effect of a one standard deviation cut in the federal funds rate on two-year Black employment growth across labor markets in each decile of tightness in the fourth quarter of 2000.[8] We plot the additional employment growth predicted for each decile (based on its mean employment-to-population ratio) relative to that for the lowest decile. The figure shows the substantial heterogeneity across labor markets in the effect of a monetary expansion on subsequent Black employment growth: after a monetary expansion, Black employment grows more rapidly in tighter labor markets. The estimates predict that a one standard deviation drop in the federal funds rate in Q4 of 2000 would have increased subsequent 2-year black employment growth by a quarter percentage point more in labor markets in the second decile of tightness than in the first. The effect is larger in each incremental decile, with the relative effect being twice as large in the fourth decile than in the second decile, more than three times as large in the seventh decile, and more than five times as large in the tenth

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[7]The industry-by-quarter and industry-by-location fixed effects ensure that this identification is achieved after netting out the average rates of employment growth both in that location-industry over time and in that industry-quarter across locations.

[8]Figures for other points in time look similar with slight variations arising from the contemporaneous distribution of labor market tightness across deciles.

decile.

The employment response of Whites, however, differs from that of Blacks. Column 2 of Table 3 reports estimates of equation (3) for Whites. In contrast to Blacks, the $\beta_1$ coefficient for Whites is much smaller and not statistically significant. This coefficient implies that White employment growth's sensitivity to the federal funds rate does not depend on the degree of local labor market tightness. The difference in the Black and White coefficient estimates is highly statistically significant ($p < 0.01$).

Panel B of Table 3 presents a similar heterogeneity analysis with respect to educational attainment, reporting results for those who did not complete high school in column 3, high school graduates in column 4, those with some college education in column 5, and bachelor's degree holders in column 6.[9] We find that in response to monetary easing, the increase in employment growth among workers who did not complete high school is larger when labor markets are tight than when they are slack (column 3). The $\beta_1$ coefficient implies that a one standard deviation drop in the federal funds rate is associated with 0.39 percentage point greater two-year employment growth in tight labor markets (90th percentile) than in slack ones (10th percentile). This magnitude corresponds to approximately 18% of unskilled workers' mean two-year employment growth.

For workers with greater educational attainment, in contrast, the $\beta_1$ coefficient estimates are close to zero and not statistically significant (columns 4-6). The point estimates are similar across these three more educated groups, implying that the sensitivity of employment growth to monetary easing is less dependent on the degree of slack in the labor market for workers who completed high school. The coefficient for workers who did not complete high school is statistically different from the three remaining coefficient estimates. For example, the $p$-value of the difference between the coefficients for those who did not complete high school and those with a bachelor's degree is 0.001. The difference between these coefficients for each of the three groups with greater educational attainment are not statistically significant.

Panel C of Table 3 examines employment growth separately among men and women. We again find heterogeneous effects: The point estimates of the interaction coefficient, $\beta_1$, is an order of magnitude larger in absolute value for women than for men (-0.26 vs. -0.03). Although neither coefficient is statistically different from zero in this specification, the two coefficients are statistically different from one another ($p$-value = 0.02).[10]

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[9]Data are not available in the QWI to conduct the analysis at the race-by-education level.

[10]As shown below, the $\beta_1$ coefficient for women is statistically significant in both reduced form and 2SLS specifications examining the effects of high frequency monetary shocks.

To examine the short- and long-term dynamic responses of employment growth, we use a rolling window framework. Figure 2 depicts the impact of monetary policy on employment growth over a one-year horizon starting at different time periods following the monetary policy rate change. For each time period $p$, beginning one quarter to 16 quarters out, we estimate the following specification:

$$EmplGrowth^p_{j,g,m,t} = \beta_1 \times FedFunds_t \times Empl/Pop_{m,t-1} +$$
$$\beta_2 \times Empl/Pop_{m,t-1} + \theta_{j,m} + \delta_{j,t} + \epsilon_{j,g,m,t}, \quad (4)$$

where $EmplGrowth^p_{j,g,m,t}$ is the growth rate of employment for demographic group $g$ from the beginning of quarter $t + p$ through the end of quarter $t + p + 3$ in industry $j$ and local labor market $m$. All other variables are as in equation (3). Figure 2 plots the $\beta_1$ coefficients obtained from these one-year rolling window regressions.

The figure shows that the effects of monetary policy described in Table 3 have a long-term impact. Panel A, which presents the results by race, indicates that the differential incremental impact of monetary policy on Black employment growth in tight versus slack labor markets reaches a peak starting seven quarters after the monetary policy change. The $\beta_1$ coefficient declines in absolute value subsequently and is approximately zero by quarter 15. In contrast, the effect on White employment growth is consistently close to zero across all time periods. Panels B and C show similar results when examining differences by education and sex, respectively. The $\beta_1$ coefficient for workers without a high school diploma and for women declines in absolute value beginning in quarter 9.

Although monetary policy's incremental effect on Black, low-education, and female employment growth wanes over time, its cumulative effect is long-lasting. Figure 3 depicts the relation between cumulative employment growth and the interaction of the federal funds rate and labor market tightness. For each demographic group, we re-estimate equation (3) for cumulative employment growth measured over different horizons from one quarter up to 16 quarters. Figure 3 plots the $\beta_1$ interaction coefficients obtained from each of these regressions. The eight-quarter estimates are the same as those reported in Table 3. Panel A presents results by race, Panel B by education, and Panel C by sex. In all three cases, the heterogeneity in the cumulative effect is long lasting. Focusing, for example, on Panel A, the figure shows that the differential effect of monetary policy on cumulative black employment growth in tight versus slack labor markets persists even four years following the shock. Further, $\beta_1$ is larger in absolute value for Blacks than for Whites at every horizon with the difference between the

coefficients statistically significant at the 1% level at every horizon longer than five quarters.[11]

Even though our analysis is at the MSA level and controls for economic conditions using industry-by MSA and industry-by-quarter fixed effects, a potential concern is that developments in the federal funds rate are endogenous and correlated with variables affecting local employment growth. Because decreases in the federal funds rate tend to occur in response to deteriorations in the economy, the coefficients in Table 3 will be biased upwards (i.e., less negative) if employment growth in slack labor markets is more pro-cyclical. To alleviate this concern, we examine the effects of unexpected changes in monetary policy, identified using high frequency movements in the federal funds futures rate around FOMC announcements, following Kuttner (2001) and others. We use the running sum of these high frequency monetary shocks to instrument for the federal funds rate within a 2SLS framework. This 2SLS estimation is in the spirit of Gertler and Karadi (2015), who use these high frequency monetary shocks as an external instrument within a structural VAR framework. Because the running sum of monetary shocks is highly predictive of the federal funds rate, it is a valid instrument under the assumption that no other news about the economy is revealed during the 30-minute window around the FOMC meeting.

As a first step in this analysis, we re-estimate our baseline specification (equation 3) after replacing the federal funds rate with the high-frequency shocks. In the instrumental variables approach, this specification is the reduced form regression, wherein we examine the relation between the dependent variable and the instrument itself. The results are reported in Table 4.

This analysis that directly examines the monetary shocks yields qualitatively similar results to our analysis that examines the federal funds rate, reported above in Table 3. Panel A of Table 4 shows that, whereas an expansionary monetary policy shock leads to higher Black employment growth in tighter labor markets (column 1; $p < 0.05$), White employment growth does not depend on labor market tightness in a statistically significant manner. Similarly, the education group least attached to the labor force—workers without a high school diploma—is more sensitive to monetary policy shocks in tight labor markets than in slack ones (Panel B). Further, whereas monetary expansions lead to greater employment growth in tighter labor markets for women, this effect is not statistically significant for men (Panel C). For each of these demographic categories, these differences across groups are statistically significant.

Finally, to measure the effect of changes in the federal funds rate itself, we run a 2SLS specification in which we use the high-frequency monetary policy shocks to instrument for the federal funds rate. Specifically, we instrument for the interaction between the federal funds

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[11]This difference is statistically significant at the 5% level at every horizon longer than one quarter.

rate and the local employment-to-population ratio using the interaction between the monetary shocks and the local employment-to-population ratio. Panel A of Table 5 reports the results of the first stage equation:[12]

$$FedFunds_t \times Empl/Pop_{m,t-1} = \alpha_1 \times MonetaryShock_t \times Empl/Pop_{m,t-1} +$$
$$\alpha_2 \times Empl/Pop_{m,t-1} + \theta_{j,m} + \delta_{j,t} + \eta_{j,g,m,t}, \quad (5)$$

where $MonetaryShock_t$ is the high-frequency monetary shock variable in quarter $t$. As Panel A shows, the coefficient of interest, $\alpha_1$, is positive and highly statistically significant ($p < 0.001$). The first stage F-statistic is 4984, leaving no concern that $MonetaryShock$ is a weak instrument.

The remaining panels of Table 5 present the results of the instrumental variable analysis, which estimates a specification similar to equation (3) but that substitutes the predicted values from equation (5) for the federal funds rate times employment-to-population ratio interaction. Compared to the analogous OLS estimates reported in Table 3, the IV estimates in Table 5 are slightly larger in magnitude (i.e., more negative). The difference between the estimates suggests that the covariate of interest $FedFunds_t \times Empl/Pop_{m,t-1}$ might be positively correlated with an omitted determinant of employment growth in the OLS specification. Because the Fed eases monetary policy during economic downturns, we would expect the OLS estimates to be upward biased if employment growth is more pro-cyclical in slack labor markets.

Panel B of Table 5 reports results by race. Monetary policy expansions lead to larger increases in Black employment growth when the labor market is tighter (Column 2). The coefficient implies that a one standard deviation drop in the federal funds rate increases subsequent two-year Black employment growth by 1.02 percentage points more in tight labor markets (90th percentile) than in slack labor markets (10th percentile). This additional boost to employment growth in tighter labor markets is substantial, corresponding to 10.2% of the mean Black employment growth over the sample period. In contrast, the 2SLS coefficient for Whites (column 3) is statistically insignificant and trivial in magnitude. The difference between the two coefficients is statistically significant at the 1% level. These estimates imply that the impact of monetary easing on employment growth does not depend on labor market tightness for Whites as it does for Blacks.

Results across education groups are reported in Panel C. The coefficient for those who did not complete high school (column 4) is more than three times as large as the coefficients

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[12]While Panel A reports the results of the first stage equation in the context of the analysis of Black employment growth, we obtain very similar results for the samples corresponding to the other demographic groups.

for each of the three other education groups (columns 5-7) and is statistically different from them. For example, the *p*-value of the difference between the coefficients for those who did not complete high school and those with a bachelor's degree is less than 0.001.[13] The point estimate implies that a standard deviation drop in the federal funds rate increases the two-year employment growth of workers who did not complete high school by 0.55 percentage points more in tight labor markets (90th percentile) than in slack ones (10th percentile). For these unskilled workers, this additional impact of monetary policy in tighter labor markets corresponds to 26% of their average two-year employment growth over the sample period.

Finally, Panel D shows IV estimates of the effects on females and males. The IV estimates are again larger in magnitude than the OLS estimates, and we continue to find heterogeneous effects. Monetary expansions boost women's employment more in tight labor markets than in slack ones (column 8). A one standard deviation drop in the federal funds rate is associated with a growth in female employment that is 0.37 percentage points higher in tight labor markets (90th percentile) than in slack ones (10th percentile). The coefficient estimate for men is one-half of what it is for women, and the difference between the two coefficients is statistically significant at the 7% level.

Taken together, these results show consistent evidence that monetary policy has heterogeneous effects on employment across demographic groups. They also present a common pattern: expansionary monetary policy promotes employment of demographic groups with historically lower labor market attachment—Blacks, the least educated, and women—the most when labor markets are tight. For these groups, the impact of monetary policy in tight labor markets lasts several years. In contrast, this pattern is muted or nonexistent for groups with greater labor market attachment—Whites, skilled workers, and men.

The results thus suggest that sustained expansionary monetary policy, which allows the labor markets to tighten significantly, might be required to generate robust employment growth among workers who are less attached to the labor market. We show that, as long as labor markets are slack, the impact of monetary policy on Blacks, unskilled workers, and women is muted. Next, we explore the implications of this heterogeneity for monetary policy in the context of a heterogeneous agent New Keynesian model.

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[13]The differences between the coefficients for the three groups with greater educational attainment are not statistically significant.

# III   Model

Our empirical results show that in tight labor markets less attached segments of the labor force are more sensitive to monetary policy shocks. In this section, we model an economy with heterogeneous workers to examine the underpinnings of this empirical regularity and to perform counterfactual analysis. In the model, workers differ in their productivity. We do not model the sources of variation in workers' productivity, which could stem from differences in education levels, labor market experience, worker-firm match quality, on-the-job discrimination, workplace harassment, or other factors. The model considers two types of workers whose worker-specific productivity are drawn from different subsets of the unit interval, leading to persistent differences in average productivity across workers of different types. All else equal, these different levels of average productivity map into different levels of steady state employment, which is the model equivalent of labor force attachment.

Workers consume output and supply labor to firms. Following Galí (2011b), we assume labor is indivisible: in each period, an individual either works a fixed number of hours or does not work at all. All variation in labor input thus takes place at the extensive margin. Workers separate from firms for both exogenous and endogenous reasons. We model the search and hiring decisions following Ravenna and Walsh (2012). In this section, we introduce the different model ingredients and then calibrate the model in the next section to study how monetary policy shocks affect the employment of workers of different types.

## A.   Timing

The timing and information structure of the model are as follows:

1. Exogenous separation. A fraction $\delta \in [0,1]$ of workers separate from their firms.

2. Productivity revelation. Aggregate productivity $A_t$ and each worker's period-specific individual productivity $a_{i,t}$ are realized. Aggregate productivity and workers' types are common knowledge. An individual worker's productivity level is i.i.d. over time and drawn from a distribution that depends on the worker's type. A worker's productivity level is observable to the firm that employs the workers.

3. Endogenous separation. Firms choose to fire workers based on each worker's productivity.

4. Hiring. Firms employ third-party agencies to select workers for them to hire. Unemployed workers—both those who entered the period unemployed and those who

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separated—search for work. Hiring agencies observe whether a worker was endogenously separated and choose whom to interview. The interviews reveal workers' productivity levels.

5. Production occurs and wages are paid.

## B. Households

A representative household exists consisting of a continuum of workers of two types, high ($h$) and low ($l$), with a mass $\gamma$ of high types and a mass $1 - \gamma$ of low types. A high type's productivity is drawn from a uniform distribution on the support $[\underline{s}, 1]$, whereas a low type's productivity is drawn from the support $[0, \bar{s}]$, where $\underline{s} > 0$ and $\bar{s} < 1$.

We assume that utility is separable between consumption and the disutility of work. Individuals display habit formation over aggregate consumption, which leads macro quantities including output to exhibit humped-shaped responses to shocks. Utility is given by:

$$U_t = \frac{1}{1 - \sigma}(C_t - \hbar C_{t-1})^{1-\sigma} - (N_{h,t}^\chi + N_{l,t}^\chi)/\chi, \tag{6}$$

where $\sigma$ is the intertemporal elasticity of substitution, $\chi \geq 1$ is a measure of disutility due to working, $\hbar > 0$ measures the strength of habit formation, and $N_{h,t}$ and $N_{l,t}$ are the number of high and low type workers working in period $t$, respectively. Consumption and the aggregate price index, $C_t$ and $P_t$, are given by:

$$C_t = \left( \int_0^1 C_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{1-\epsilon}} \tag{7}$$

and

$$P_t = \left( \int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}. \tag{8}$$

Let $C_t(i)$ and $P_t(i)$ be the consumption and price, respectively, of goods produced by firm $i$; and let $\epsilon$ be the elasticity of substitution between goods produced by different firms.

The demand for good $i$ is given by:

$$C_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\epsilon} C_t \tag{9}$$

and the household budget constraint in each period is:

$$W_{h,t}N_{h,t} + W_{l,t}N_{l,t} + D_t = C_tP_t, \tag{10}$$

where $W_{h,t}$ and $W_{l,t}$ are the nominal wages of the high and low types, respectively and $D_t$ equal the profits of firms and the hiring agency that are paid as dividends to the household. The first order conditions for labor supply and consumption are given by:

$$\frac{N_{k,t}^{\chi-1}}{Z_t} = \frac{W_{k,t}}{P_t} \quad \text{for } k = h, l \tag{11}$$

$$Q_t = \beta E_t \left( \frac{Z_{t+1}}{Z_t} \frac{P_t}{P_{t+1}} \right), \tag{12}$$

where

$$Z_t = (C_t - hC_{t-1})^{-\sigma} - h\beta E_t (C_{t+1} - hC_t)^{-\sigma} \tag{13}$$

is the marginal utility of consumption, $Q_t$ is the stochastic discount factor, and $\beta$ is the subjective time discount factor.

## C. Labor Market

We denote by $\bar{a}_{k,t}$ the time $t$ productivity threshold above which a worker of type $k$ is profitable to hire, and $\underline{a}_{k,t}$ is the productivity threshold below which a worker is profitable to fire. Because of hiring costs, $\bar{a}_{k,t} > \underline{a}_{k,t}$. These thresholds are the model's key dynamic parameters.

The unemployment level immediately after exogenous separation is given by:

$$U_{h,t} = \gamma - (1 - \delta)N_{h,t-1} \tag{14}$$

$$U_{l,t} = 1 - \gamma - (1 - \delta)N_{l,t-1}. \tag{15}$$

Total employment, evolves according to:

$$N_{h,t} = P(a_{h,t} > \underline{a}_{h,t})(1 - \delta)N_{h,t-1} + H_{h,t} = \left( 1 - \frac{a_{h,t} - \underline{s}}{1 - \underline{s}} \right)(1 - \delta)N_{h,t-1} + H_{h,t} \tag{16}$$

$$N_{l,t} = P(a_{l,t} > \underline{a}_{l,t})(1 - \delta)N_{l,t-1} + H_{l,t} = \left( 1 - \frac{a_{l,t}}{\bar{s}} \right)(1 - \delta)N_{l,t-1} + H_{l,t}, \tag{17}$$

where $H_{k,t}$ is the number of hires of type $k$ in period $t$. Employment at time $t$ equals employment at time $t - 1$ minus time $t$ exogenous and endogenous separations (governed by $\delta$ and

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$\underline{a}_{k,t}$, respectively) plus time $t$ hires (governed by $\bar{a}_{k,t}$). For tractability, we assume the labor market is efficient, which implies that the agency interviews all eligible candidates and that all workers who exceed the hiring threshold are hired. Hence:

$$H_{h,t} = \left(1 - \frac{a_{h,t} - \underline{s}}{1 - \underline{s}}\right) U_{h,t} \tag{18}$$

$$H_{l,t} = \left(1 - \frac{a_{l,t}}{\bar{s}}\right) U_{l,t}. \tag{19}$$

Therefore, the law of motions of employment simplify to:

$$N_{h,t} = \frac{1}{1 - \underline{s}} \left[\gamma(1 - \bar{a}_{h,t}) + (1 - \delta)(\bar{a}_{h,t} - \underline{a}_{h,t})N_{h,t-1}\right] \tag{20}$$

$$N_{l,t} = \frac{1}{\bar{s}} \left[(1 - \gamma)(\bar{s} - \bar{a}_{l,t}) + (1 - \delta)(\bar{a}_{l,t} - \underline{a}_{l,t})N_{l,t-1}\right]. \tag{21}$$

## D. Hiring

Hiring is outsourced to a third-party agency that interviews workers for the firm. The firm specifies hiring thresholds, $\bar{a}_{h,t}$ and $\bar{a}_{l,t}$, for the agency to use when screening candidates and pays a fee per worker hired. In equilibrium, the hiring threshold is greater than the firing threshold, and so the agency chooses not to interview endogenously separated workers.

Interviewing a worker requires a fixed amount of labor $F$, with wages in the third-party agency pinned to $W_{k,t}$. The monetary cost of interviewing a worker is therefore

$$G_{k,t} = F W_{k,t}. \tag{22}$$

In expectation, because the hiring agency needs to conduct more interviews per hire when searching for workers with higher productivity, the expected cost per worker hired is increasing in the hiring threshold $\bar{a}_{k,t}$. Specifically, the expected cost per worker hired is $\frac{G_{h,t}}{1 - \frac{\bar{a}_{h,t} - \underline{s}}{1 - \underline{s}}}$ and $\frac{G_{l,t}}{1 - \frac{\bar{a}_{l,t}}{\bar{s}}}$ for high and low types, respectively. To see this, note that the expected number of interviews to hire a high type is $\frac{1}{1 - \frac{\bar{a}_{h,t} - \underline{s}}{1 - \underline{s}}}$ and it is $\frac{1}{1 - \frac{\bar{a}_{l,t}}{\bar{s}}}$ to hire a low type. Since the market for hiring agencies is perfectly competitive, $\frac{G_{h,t}}{1 - \frac{\bar{a}_{h,t} - \underline{s}}{1 - \underline{s}}}$ and $\frac{G_{l,t}}{1 - \frac{\bar{a}_{l,t}}{\bar{s}}}$ are also the fees that the firm pays to hire workers with productivity above the hiring threshold.

We assume that the hiring agency rebates the money it earns to the representative household who owns the agency.

## *E.* **Intermediate Goods Firms**

Intermediate firms of mass 1 operate in competitive markets and produce output using labor as the only factor of production. Each period, they set the hiring thresholds $\bar{a}_{h,t}$ and $\bar{a}_{l,t}$ equal to the minimum productivity levels for which it is profitable to hire workers. Similarly, firms set the firing thresholds $\underline{a}_{h,t}$ and $\underline{a}_{l,t}$ equal to the productivity level below which it is not profitable to retain a worker.

Intermediate firms have fully flexible prices and produce output $X_t(j)$ using a common technology, which is given by:

$$X_t(j) = A_t \psi_t(j) N_t(j), \tag{23}$$

where $A_t$ is the aggregate technology level that is common across firms, $\psi_t(j)$ measures the average worker productivity of firm $j$, and $N_t(j)$ is the number of workers hired.

We can rewrite $X_t(j)$ as:

$$X_t(j) = A_t \left\{ \frac{\gamma}{1 - \underline{s}} \left[ (1 - \delta) \int_{\underline{a}_{h,t}}^{1} a \, da + \delta \int_{\bar{a}_{h,t}}^{1} a \, da \right] + \frac{1 - \gamma}{\bar{s}} \left[ (1 - \delta) \int_{\underline{a}_{l,t}}^{\bar{s}} a \, da + \delta \int_{\bar{a}_{l,t}}^{\bar{s}} a \, da \right] \right\}.$$

Simplifying, we get,

$$X_t(j) = \frac{A_t}{2} \left( \frac{\gamma}{1 - \underline{s}} \left[ (1 - \delta)(1 - \underline{a}_{h,t}^2) + \delta(1 - \bar{a}_{h,t}^2) \right] + \frac{1 - \gamma}{\bar{s}} \left[ (1 - \delta)(\bar{s}^2 - \underline{a}_{l,t}^2) + \delta(\bar{s}^2 - \bar{a}_{l,t}^2) \right] \right). \tag{24}$$

We assume firms have all bargaining power and hence only need to pay a wage that makes workers willing to participate in the labor force (see equation (11)). Firms and workers bargain every period, so the wage rate is determined by the bargaining problem on a period-by-period basis (see Pissarides (2000)). Because the labor market is efficient, workers always search and work if the participation condition is satisfied and firms rebate any profits they make as dividends to the household which owns them.

At the firing threshold, $\underline{a}_{k,t}$, the firm is indifferent between firing and not firing the marginal worker of type $k$. The nominal wage is thus equal to the nominal benefit of retaining the marginal worker, which equals the sum of the worker's output in the current period and the option value, $V_{k,t}$, of retaining the worker and learning his or her updated productivity

next period without conducting a hiring interview:

$$W_{k,t} = P_t^I A_t \underline{a}_{k,t} + V_{k,t}, \tag{25}$$

where $P_t^I$ is the price index of intermediate goods and reflects the firm's marginal costs:

$$P^I = \gamma W_{h,t} \left[ 1 - \frac{\underline{a}_{h,t} - \underline{s}}{1 - \underline{s}} - \delta \frac{\bar{a}_{h,t} - \underline{a}_{h,t}}{1 - \underline{s}} \right] + (1 - \gamma) W_{l,t} \left[ 1 - \frac{\underline{a}_{l,t}}{\bar{s}} - \delta \frac{\bar{a}_{l,t} - \underline{a}_{l,t}}{\bar{s}} \right]. \tag{26}$$

Similarly, at the hiring threshold, $\bar{a}_{k,t}$, the firm is indifferent between hiring and not hiring the marginal worker of type $k$. The total cost (interviewing costs and wages) of hiring the marginal worker is thus equal to the total benefit (output and option value of retaining the worker) of hiring the worker:

$$\frac{G_l}{1 - \frac{\bar{a}_{l,t}}{\bar{s}}} + W_{l,t} = P_t^I A_t \bar{a}_{l,t} + V_{l,t} \tag{27}$$

$$\frac{G_h}{1 - \frac{\bar{a}_{h,t} - \underline{s}}{1 - \underline{s}}} + W_{h,t} = P_t^I A_t \bar{a}_{h,t} + V_{h,t}. \tag{28}$$

Given equation ((25)), the hiring thresholds thus satisfy:

$$\frac{G_{l,t}}{1 - \frac{\bar{a}_{l,t}}{\bar{s}}} = P_t^I A_t (\bar{a}_{l,t} - \underline{a}_{l,t}) \tag{29}$$

$$\frac{G_{h,t}}{1 - \frac{\bar{a}_{h,t} - \underline{s}}{1 - \underline{s}}} = P_t^I A_t (\bar{a}_{h,t} - \underline{a}_{h,t}). \tag{30}$$

The option value $V_{k,t}$ is given recursively by:

$$V_{h,t} = \beta (1 - \delta) \mathbb{E}_t \left[ \frac{Z_{t+1}}{Z_t} \left[ \left( 1 - \frac{\underline{a}_{h,t+1} - \underline{s}}{1 - \underline{s}} \right) (G_{h,t+1} + V_{h,t+1}) \right] \right] \tag{31}$$

$$V_{l,t} = \beta (1 - \delta) \mathbb{E}_t \left[ \frac{Z_{t+1}}{Z_t} \left[ \left( 1 - \frac{\underline{a}_{l,t+1}}{\bar{s}} \right) (G_{l,t+1} + V_{l,t+1}) \right] \right]. \tag{32}$$

For simplicity, we focus only on next periods' option value because the probability of worker retention beyond one period is small given i.i.d productivity draws and exogenous separation $\delta$:

$$V_{h,t} = \beta (1 - \delta) \mathbb{E}_t \left[ \frac{Z_{t+1}}{Z_t} \left[ \left( 1 - \frac{\underline{a}_{h,t+1} - \underline{s}}{1 - \underline{s}} \right) G_{h,t+1} \right] \right] \tag{33}$$

$$V_{l,t} = \beta (1 - \delta) \mathbb{E}_t \left[ \frac{Z_{t+1}}{Z_t} \left[ \left( 1 - \frac{\underline{a}_{l,t+1}}{\bar{s}} \right) G_{l,t+1} \right] \right]. \tag{34}$$

Combining these equations with equation (25) allows us to describe the dynamics of the firing threshold.

## F. Final Goods Firms

We follow Walsh (2005) and Blanchard and Galí (2010) and introduce final goods firms to avoid an interaction between wage and price setting. In particular, we assume that a continuum of final goods firms distributed on the unit interval produce varieties of differentiated products in monopolistically competitive markets using identical technology:

$$Y_t(i) = X_t(i), \tag{35}$$

where $X$ represents the quantity of intermediate goods used in the production of final goods. Final firms act like retailers: they purchase intermediate goods and sell them in final goods markets.

The real marginal cost of final goods firms is:

$$MC_t = \frac{P_t^I}{P_t}. \tag{36}$$

Market clearing dictates:

$$Y_t = C_t. \tag{37}$$

Assume that final-goods firms can only adjust their output price in each period with a constant Calvo probability of $(1 - \theta)$. Hence, the aggregate price level is given by:

$$P_t = ((1 - \theta)(P_t^*)^{1-\epsilon}) + \theta (P_{t-1})^{1-\epsilon})^{\frac{1}{1-\epsilon}}. \tag{38}$$

A firm able to reset prices in period $t$, $P_t^*$, will do so according to:

$$E_t \left\{ \sum_{l=0}^{\infty} \theta^l Q_{t,t+l} Y_{t,t+l|t} \left( P_t^* - \frac{\epsilon}{1-\epsilon} P_{t+l} MC_{t+k} \right) \right\} = 0. \tag{39}$$

Let $p_t$, $p_t^i$ and $\pi_t$ be the log-linearized values of $P_t$, $P_t^I$ and inflation, $\Pi_t = P_t/P_{t-1}$, respectively. The log-linearized New Keynesian Philips Curve is given by:

$$\pi_t = \beta E_t[\pi_{t+1}] + \lambda (p_t^i - p_t), \tag{40}$$

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where $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ and $p_t^i - p_t$ is final goods firms' log-linearized real marginal cost.

## *G.* Monetary Policy

The central bank sets a short terms policy rate $i$ with interest-rate smoothing following Coibion and Gorodnichenko (2012):

$$
\begin{aligned}
i_t^* &= \phi_\pi \pi_t + \phi_y y_t + \mu_t, \\
i_t &= (1 - \rho_i)i_t^* + \rho_i i_{t-1}, \\
\mu_t &= \rho_\mu \mu_{t-1} + \epsilon_t,
\end{aligned}
\tag{41}
$$

where $\phi_\pi$ and $\phi_y$ are the coefficients in the Taylor rule on log-linearized inflation $\pi$ and output $y$, respectively. The parameter $\rho_i$ governs the degree of policy smoothing in the nominal interest rate, the parameter $\rho_\mu$ governs the degree of persistence in interest rate shocks, and $\epsilon_i$ is an i.i.d. monetary policy innovation.

## *H.* Steady State and Log-Linearized System

We use lower case letters to denote the log-linearized versions of variables represented by capital letters with the exception of $A_t$, $\bar{a}_{k,t}$, and $\underline{a}_{k,t}$, whose log-linearized versions are denoted by $\hat{A}_t$, $\hat{a}_{k,t}$, and $\hat{\alpha}_{k,t}$, respectively. Furthermore, let $\bar{a}_k$ and $\underline{a}_k$ be the steady state values of $\bar{a}_{k,t}$ and $\underline{a}_{k,t}$, respectively. The log-linearized system of equations describing the model can then be written as follows:

Share of workers employed:

$$
n_{h,t} = \frac{1}{1 - \underline{s}} \left[ \left( 1 - \delta - \frac{\gamma}{N_h^{ss}} \right) \bar{a}_h \hat{a}_{h,t} - (1 - \delta)\underline{a}_h \hat{\alpha}_{h,t} + (1 - \delta)(\bar{a}_h - \underline{a}_h)n_{h,t-1} \right]
\tag{42}
$$

$$
n_{l,t} = \frac{1}{\bar{s}} \left[ \left( 1 - \delta - \frac{1 - \gamma}{N_l^{ss}} \right) \bar{a}_l \hat{a}_{l,t} - (1 - \delta)\underline{a}_l \hat{\alpha}_{l,t} + (1 - \delta)(\bar{a}_l - \underline{a}_l)n_{l,t-1} \right]
\tag{43}
$$

$$
n_t = \frac{N_h^{ss} n_{h,t} + N_l^{ss} n_{l,t}}{N_h^{ss} + N_l^{ss}},
\tag{44}
$$

where $N_h^{ss} = \frac{\gamma\left(\frac{1-\bar{a}_h}{1-\underline{s}}\right)}{1-(1-\delta)\left(\frac{\bar{a}_h-\underline{a}_h}{1-\underline{s}}\right)}$, $N_l^{ss} = \frac{(1-\gamma)\left(\frac{\bar{s}-\bar{a}_l}{\bar{s}}\right)}{1-(1-\delta)\left(\frac{\bar{a}_l-\underline{a}_l}{\bar{s}}\right)}$, and $N^{ss} = N_h^{ss} + N_l^{ss}$.

Marginal utility:

$$z_t = \frac{-\sigma}{(1-\hbar)(1-\hbar\beta)}\left((c_t - \hbar c_{t-1}) - \hbar\beta(c_{t+1} - \hbar c_t)\right). \tag{45}$$

First-order condition for consumption:

$$c_t = \frac{\hbar}{1+\hbar^2\beta}c_{t-1} + \frac{\hbar}{1+\hbar^2\beta}\beta E_t[c_{t+1}] - \frac{(1-\hbar)(1-\hbar\beta)}{\sigma(1+h^2\beta)}E_t[\sum_{j=1}^{\infty}(i_t - E_t\pi_{t+1})]. \tag{46}$$

Inflation:

$$\pi_t = p_t - p_{t-1}. \tag{47}$$

Nominal wage rate:

$$w_{h,t} = (1-\chi)n_{h,t} - z_t + p_t \tag{48}$$

$$w_{l,t} = (1-\chi)n_{l,t} - z_t + p_t. \tag{49}$$

Cutoff determination of the firing thresholds:

$$p_t^i + \hat{A}_t - w_{h,t} = -\hat{\alpha}_{h,t} - \frac{\beta(1-\delta)\left[\left(1 - \frac{a_{h,t+1}-\underline{s}}{1-\underline{s}}\right)(\chi\Delta n_{h,t+1} + \pi_{t+1}) - \frac{a_h}{1-\underline{s}}\hat{\alpha}_{h,t+1}\right]}{1 - \beta(1-\delta)\left(1 - \frac{a_{h,t+1}-\underline{s}}{1-\underline{s}}\right)F} \tag{50}$$

$$p_t^i + \hat{A}_t - w_{l,t} = -\hat{\alpha}_{l,t} - \frac{\beta(1-\delta)\left[\left(1 - \frac{a_{l,t+1}}{\bar{s}}\right)(\chi\Delta n_{l,t+1} + \pi_{t+1}) - \frac{a_l}{1-\underline{s}}\hat{\alpha}_{l,t+1}\right]}{1 - \beta(1-\delta)\left(1 - \frac{a_{l,t+1}}{\bar{s}}\right)F}. \tag{51}$$

Relation between hiring and firing thresholds:

$$w_{l,t} + \frac{\bar{a}_l}{\bar{s}\left(1 - \frac{\bar{a}_l}{\bar{s}}\right)}\hat{a}_{l,t} = p_t^I + \hat{A}_t + \frac{\bar{a}_l\hat{a}_{l,t} - \underline{a}_l\hat{\alpha}_{l,t}}{\bar{a}_l - \underline{a}_l} \tag{52}$$

$$w_{h,t} + \frac{\bar{a}_h}{(1-\underline{s})\left(1 - \frac{\bar{a}_h - \underline{s}}{1-\underline{s}}\right)}\hat{a}_{h,t} = p_t^I + \hat{A}_t + \frac{\bar{a}_h\hat{a}_{h,t} - \underline{a}_h\hat{\alpha}_{h,t}}{\bar{a}_h - \underline{a}_h}. \tag{53}$$

Market clearing:

$$y_t = c_t. \tag{54}$$

Output follows from the aggregation of equation (24) after applying market clearing:

$$\hat{y}_t = \hat{A}_t - 2 \frac{\frac{\gamma}{1-\underline{s}}(1-\delta)\underline{a}_h^2 \hat{\alpha}_{h,t} + \frac{\gamma}{1-\underline{s}}\delta\bar{a}_h^2 \hat{a}_{h,t} + \frac{1-\gamma}{\bar{s}}(1-\delta)\underline{a}_l^2 \hat{\alpha}_{l,t} + \frac{1-\gamma}{\bar{s}}\delta\bar{a}_l^2 \hat{a}_{l,t}}{\frac{\gamma}{1-\underline{s}}\left[(1-\delta)(1-\bar{a}_h^2) + \delta(1-\bar{a}_h^2)\right] + \frac{1-\gamma}{\bar{s}}\left[(1-\delta)(\bar{s}^2 - \underline{a}_l^2) + \delta(\bar{s}^2 - \bar{a}_l^2)\right]}. \tag{55}$$

Finally, the log linearized model is closed with the New Keynesian Philips Curve (equation (40)) and the interest rate rule (equation (41)):

$$\pi_t = \beta E_t[\pi_{t+1}] + \lambda(p_t^i - p_t) \tag{56}$$

$$i_t^* = \phi_\pi \pi_t + \phi_y y + \mu_t \tag{57}$$

$$i_t = (1-\rho_i)i_t^* + \rho_i i_{t-1}. \tag{58}$$

## IV    Model Simulations

We calibrate the model at the quarterly frequency using the parameters listed in Table 6. The preference parameters are standard. The average quarterly degree of price stickiness $\theta$ of 0.73 implies that price spells have an average duration of 1.4 quarters, consistent with evidence from microdata (Weber (2015) and Gorodnichenko and Weber (2016)). The monetary policy specification and shock persistence parameter follow Coibion and Gorodnichenko (2012) and Pasten et al. (2019). The steady-state hiring threshold $\bar{a}$ equals 0.45 for both types. The Bureau of Labor Statistics estimates the total separation of workers to be 0.45 per year in 2019 using JOLTS. We thus assume an exogenous separation rate of 0.05 per quarter to leave room for the incidence of endogenous separation. The share of high- and low-type workers, $\gamma$, equals 0.5. In the baseline calibration, high-type workers draw their i.i.d. productivity from the interval $[0.1, 1]$, while low-type workers draw their productivity from the interval $[0, 0.75]$. Hence, this calibration implies that a larger share of high-type workers are employed in steady state. We discuss these differences in more detail below.

Figure 4 reports impulse response functions (IRFs) to a one standard deviation expansionary monetary policy shock for output, the nominal interest rate, inflation, the hiring thresholds $\bar{a}_{l,t}$ and $\bar{a}_{h,t}$, the firing thresholds $\underline{a}_{l,t}$ and $\underline{a}_{h,t}$, the share of high- and low type workers employed, and their wages. In the baseline calibration (solid blue line), an expansionary monetary policy shock increases output, wages, and inflation on impact and leads to somewhat persistent declines in the hiring and firing thresholds for both types of workers. The lower hiring and firing thresholds imply that an expansionary monetary policy shock results in more workers being hired and fewer such workers being fired.

Expansionary monetary policy differentially affects the employment of workers of different types. For both the hiring and for the firing thresholds, we observe a larger decrease for low types than for high types on impact. These effects first build up over time, with a temporary overshooting of the firing threshold for low types, before the thresholds converge back to their steady state levels. As a result, loose monetary policy particularly benefits lower productivity workers by increasing their employment levels.

Figure 4 also plots IRFs for labor markets with different degrees of initial level labor market tightness. We achieve this variation by varying the support of the productivity draws of high- and low-types. We move the lower bound of the support for high types from 0.1 in the baseline to 0.125 in the tight labor market calibration (dashed red line) and to 0.075 in the slack calibration (dashed black line). For low types, we move the upper bound of the support from 0.75 in the baseline to 0.725 in the tight calibration and to 0.775 in the slack calibration. These changes translate into different steady-state levels of employment and thus of labor market tightness. Whereas in the baseline calibration the steady-state share of employment of high types is 80.9%, this number is 83.3% in the tight labor market calibration, and 78.5% in the slack labor market calibration. For low types, the baseline steady-state share of employment is 72.5%, it is 74.8% in the tight labor market calibration, and it is 71.2% in the slack labor market calibration.

The calibration in Figure 4 shows that low-type workers especially benefit from expansionary monetary policy in tight labor markets: the hiring and firing thresholds of low-type workers exhibit larger declines in tight as compared to slack labor markets. The decline in these thresholds translate into larger employment gains. While in the slack labor market calibration the monetary shock moves the share of employed low type workers from a steady state value of 71.2% to a maximum value of 88.1%, in the tight labor market calibration, this share moves from a steady state value of 74.8% to a maximum value of 99.9%.[14] In contrast, for high types, the impact of the monetary shock is less sensitive to the initial labor tightness: the steady-state high type employment shares for the slack and tight labor market calibrations are 78.5% and 83.3%, respectively, and reach a maximum of 91.0%, and 94.7%, following the monetary expansion.

Hence, consistent with our empirical results, we find that expansionary monetary policy disproportionally benefits workers with lower productivity levels in tight labor markets. This occurs for two reasons. First, in tighter labor markets, the marginal workers who join

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[14]In the baseline labor market, the monetary shock's impact on the share of employed low-type workers lies in between the other two calibrations, moving from a steady state value of 72.5% to a maximum level of 92.1%.

the labor force in response to the monetary shock have lower productivity levels. This is a straightforward ranking effect similar to Blanchard and Diamond (1994), whereby when filling vacancies, firms begin by hiring higher productivity workers. Second, in tighter labor markets, employment expands more easily in response to a monetary shock because screening for lower productivity workers is less costly, as it takes fewer interviews to find a candidate whose productivity is above the hiring bar. Thus the hiring cost, $\frac{G_t}{1-\bar{a}_{k,t}}$, is lower in tighter labor markets, leading a monetary shock to have a larger effect on the hiring threshold.[15]

During the Great Financial Crisis and the onset of the Covid-19 pandemic, monetary policy makers aggressively cut policy rates to zero. More aggressive and larger monetary shocks are particularly helpful for low-type workers. Figure 5 compares the IRFs for monetary policy shocks of different sizes. More expansionary monetary policy results in a larger output response and a larger drop in the hiring and firing thresholds, particularly for low-type workers. Monetary policy that more aggressively lowers interest rates thus has the potential to help workers who are normally forced to the sidelines and pull them into employment.

The slope of the Philips curve also affects these relations. After recessions, central banks often start increasing interest rates preemptively to reduce inflationary pressure. Evidence from before the onset of the Covid-19 pandemic suggests that the Phillips Curve flattened (see, e.g., Simon et al. (2013) and Hall (2013)), giving rise to the criticism that preemptively increasing rates hurts minority employment and is unwarranted given the low inflationary pressure. For example, Federal Reserve Board Governor Lael Brainard stated in September 2020 that "There was no need to pre-emptively withdraw, or prepare to withdraw, on the basis of an expectation of inflation materializing" referring to the increase in the federal funds rates in 2015 (Brookings (2020)).

We model a flatter Phillips curve by increasing the degree of price stickiness in our model economy. Figure 6 plots the IRFs for three different degrees of price flexibility. Consistent with the notion that higher price stickiness results in a flatter Phillips curve, we indeed find that monetary expansions in the economy with more sticky prices result in larger output gains. Importantly, when price stickiness is high, a monetary expansion also results in larger decreases in the hiring and firing thresholds, particularly for low-type workers. With a flatter Philips curve, the central bank is able to keep interest rates lower for longer and tighten labor markets, allowing lower productivity workers to enter and remain in the work force.

In its 2020 policy review, the Federal Reserve Board reinterpreted its monetary policy

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[15]The firing threshold is tied to the hiring threshold and also exhibits larger movements to expansionary monetary policy in tighter labor markets.

objective to focus on full and inclusive employment. As part of the change in its objective, the Federal Reserve Board adjusted its policy framework from strict to average inflation targeting. To examine the effects of the Federal Reserve Board's 2020 policy change to an average (symmetric) inflation target, Figure 7 compares IRFs when the central bank uses the baseline Taylor rule to when it uses a policy rule that targets average inflation. To capture average inflation targeting, we replace the current inflation rate in the Taylor rule with the average of the current inflation rate and its eleven lags, following Svensson (2020). Consistent with the Federal Reserve Board's motivation to change their policy rule, we find that on impact average inflation targeting results in a slightly larger increase in output, larger declines in the hiring and firing thresholds, and larger increases in employment. Further, average inflation targeting is especially beneficial for low type workers, with larger increases in employment and wages than for high type workers. In unreported results, we augment our model with a government and show similar results across policy rules following government spending shocks; that is, the employment of low types is more responsive than of high types when the central bank follows an average inflation targeting framework instead of a strict inflation targeting framework when setting monetary policy.

Taken together, these counterfactual exercises suggest that the Federal Reserve's new policy framework increases the employment of workers with lower average labor force attachment, especially in tight labor markets. Tight labor markets transmit monetary expansions towards workers with lower labor force attachment. The flattening of the Philips curve further magnifies this beneficial effect of monetary policy on less attached segments of the labor force.

# V  Conclusion

Expansionary monetary policy has heterogeneous effects on the labor force, with labor market tightness playing an important mediating role. We show empirically that expansionary monetary policy benefits the employment of workers with weak labor force attachment more in tight labor markets than in slack ones. This pattern holds across racial, education, and sex categories, as the employment benefits for Blacks, high school dropouts, and women increase with labor market tightness. The beneficial impact of monetary policy on less-attached workers is economically sizeable and long lasting.

Using a New Keynesian model with workers of heterogeneous types, we analyze how labor market tightness transmits changes in monetary policy into employment growth of

workers of different types. The model predicts that the expansionary effect of monetary policy on the employment of less-attached workers is stronger in tighter labor markets. We further show that a monetary policy that follows an average inflation targeting rule particularly benefits less-attached workers. By keeping rates low for longer, employment becomes more inclusive. Similarly, a flatter Philips curve enables the central bank to maintain low rates, implying that expansionary monetary shocks lead to larger and more persistent increases in the employment of low labor force participation workers.

Our empirical and theoretical results both suggest that sustained expansionary monetary policy, which tightens labor markets, facilitates robust employment growth among less-attached workers. Our findings thus imply that the Federal Reserve's recent change in its conduct of monetary policy from strict to average inflation targeting will benefit the employment of female, minority, and low skilled workers. At the same time, expansionary monetary policy increases inflationary pressure and may also foster wealth inequality by raising asset prices (Amberg et al., 2021; Peydró et al., 2021). Managing the tradeoff between broad-based employment goals, inflation targets, and wealth inequality is an important topic of further research.

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Figure 1: **Predicted Black Employment Growth by Labor Market Tightness, Fourth Quarter 2000**
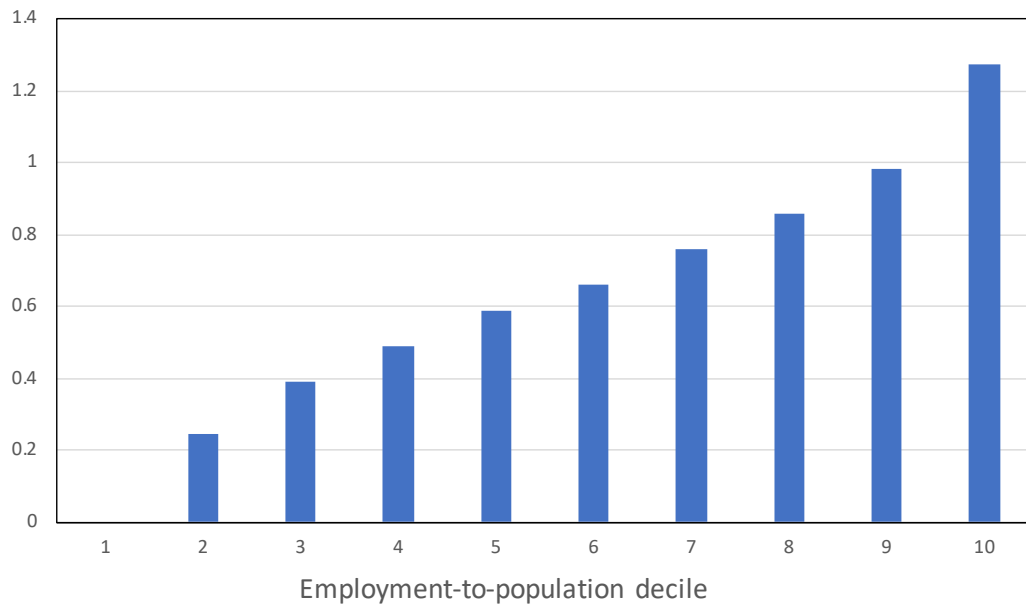


*This figure plots the predicted differential effect of a one standard deviation cut in the federal funds rate on subsequent two-year Black employment growth across labor markets of different tightness, measured using deciles of the employment-to-population ratio. The deciles of employment-to-population ratio (across MSAs) are calculated in the fourth quarter of 2000. For each decile, the figure plots the additional predicted employment growth relative to that predicted for the lowest employment-to-population decile. Predicted values are calculated from the estimates in Panel A of Table 3 using the mean employment-to-population ratio for each decile.*

## Figure 2: **Temporal Dynamics**

### Panel A. Race



### Panel B. Education



### Panel C. Sex
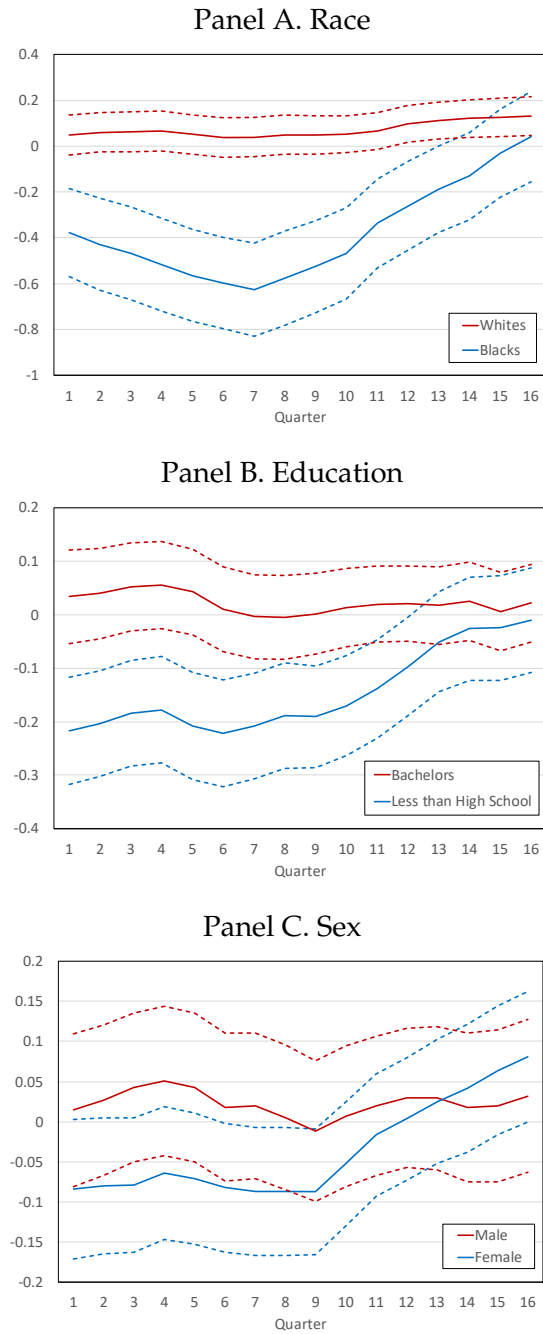


*This figure depicts the temporal dynamics of the differential impact of monetary policy on employment growth in tight versus slack labor markets. The figure shows the impact of monetary policy over a one-year horizon starting in different quarters following the monetary policy rate change for different demographic groups within three categories: race (Panel A), education (Panel B), and sex (Panel C). For each quarter, beginning one quarter to 16 quarters out, the figure plots the coefficient on the interaction term between the federal funds rate and the local prime age employment-to-population ratio in equation (4). Dashed lines present one standard deviation confidence intervals.*

## Figure 3: **Long-run Impact**

### Panel A. Race



### Panel B. Education



### Panel C. Sex
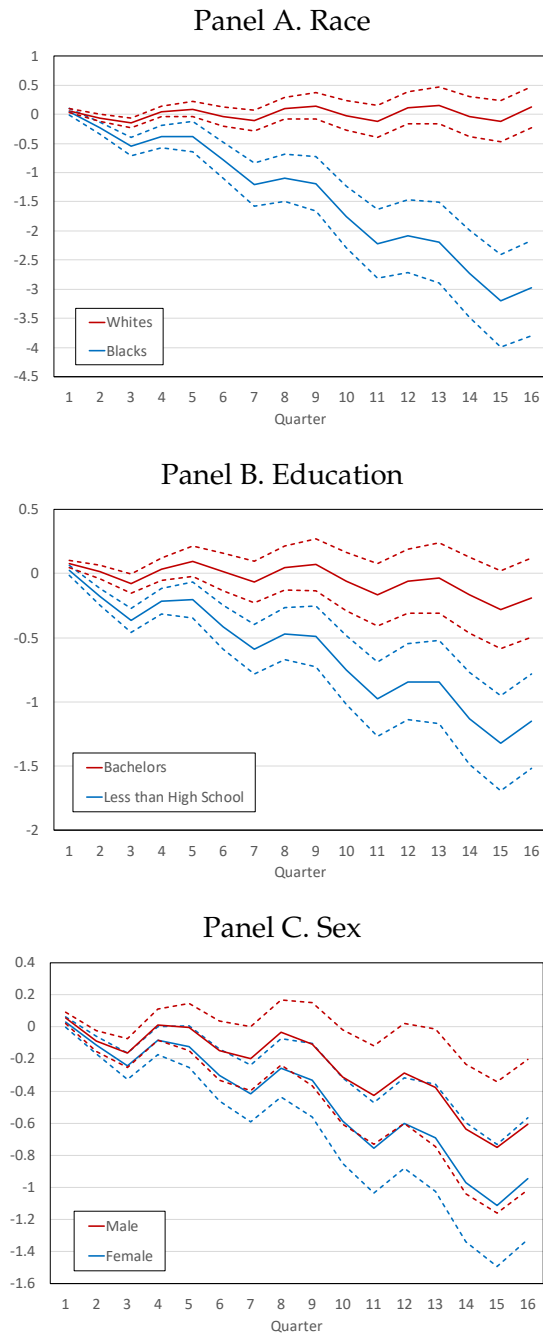


*This figure depicts the cumulative impact over time of monetary policy on employment growth in tight versus slack labor markets for different demographic groups within three categories: race (Panel A), education (Panel B), and sex (Panel C). For each demographic group, the figure depicts the relation between cumulative employment growth and the interaction of the federal funds rate and labor market tightness over horizons of one to 16 quarters. For each such time horizon, the figure plots the interaction coefficient between the federal funds rate and the local-level prime age employment-to-population ratio in equation (3), with the dependent variable equal to cumulative employment growth over that time horizon. Dashed lines present one standard deviation confidence intervals.*

Figure 4: **Impulse Response Functions for Different Steady-State Employment Levels**
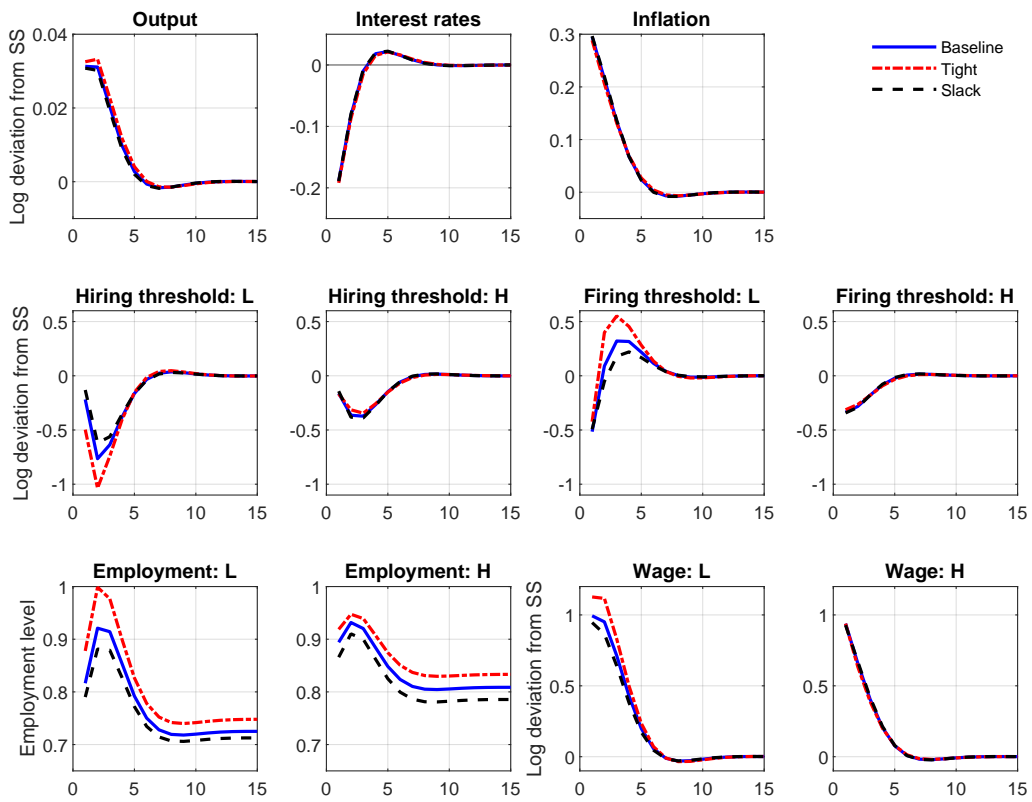


*This figure plots impulse response functions for output, interest rate, inflation, hiring thresholds, firing thresholds, the fractions of workers employed, and wages for high (H) and low (L) type workers. Response functions are plotted for three different levels of the steady-state employment, that is, labor market tightness.*

Figure 5: **Impulse Response Functions for Different Shocks Sizes**
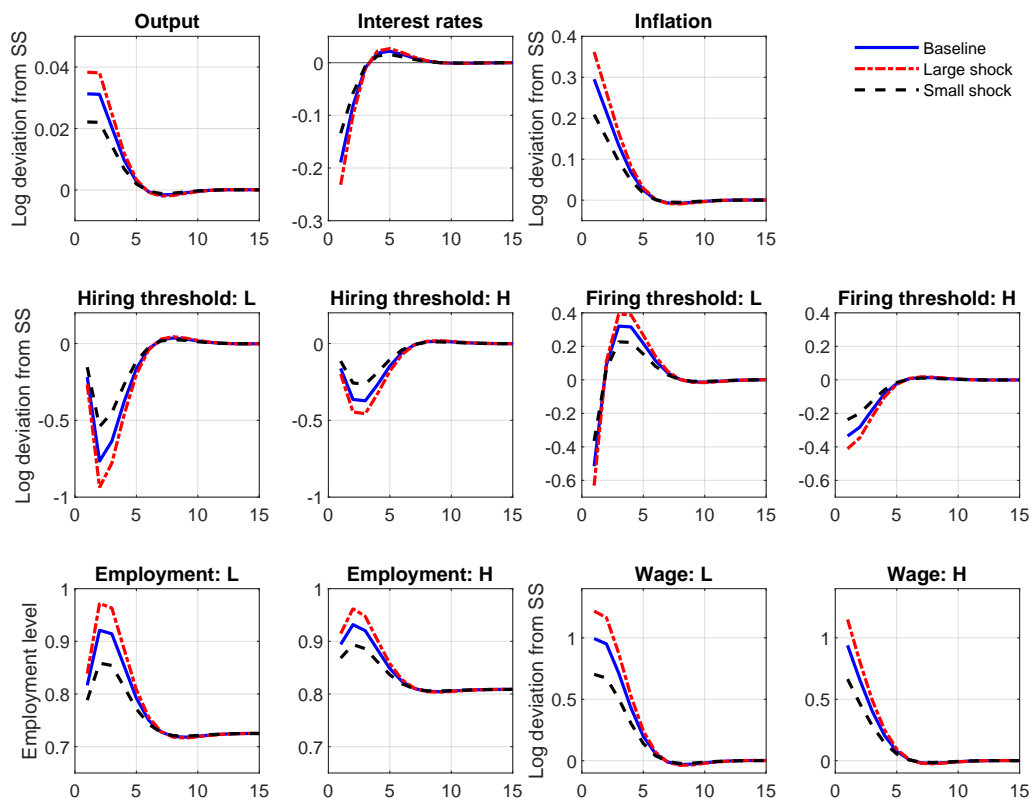
*This figure plots impulse response functions for output, interest rate, inflation, hiring thresholds, firing thresholds, the fractions of workers employed, and wages for high (H) and low (L) type workers. Response functions are plotted for monetary policy shocks of different sizes: the value of var($\epsilon^i$) is 1 in the baseline simulation (blue line), 1.5 in the large shock simulation (red line), and 0.5. in the small shock simulation.*

Figure 6: **Impulse Response Functions for Different Degrees of Price Stickiness**
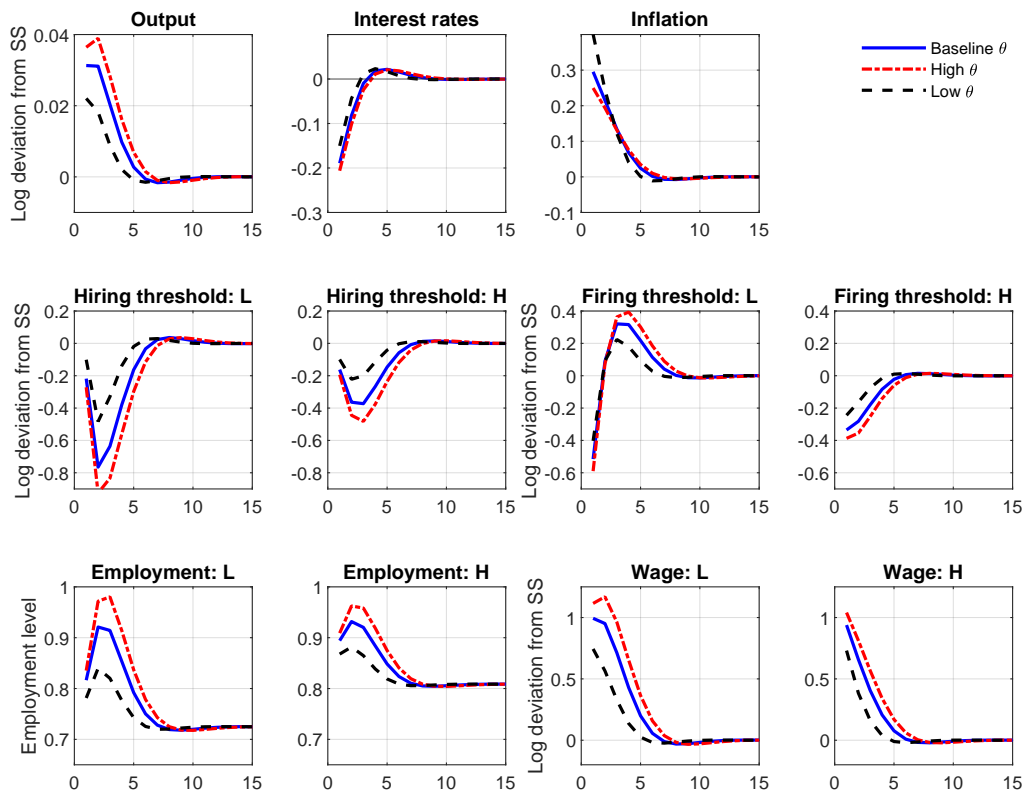


*This figure plots impulse response functions for output, interest rate, inflation, hiring thresholds, firing thresholds, the fractions of workers employed, and wages for high (H) and low (L) type workers. Response functions are plotted for different levels of price stickiness: the level of price stickiness, θ, is 0.73 in the baseline simulation (blue line), $e^{-1/4}$ in the high stickiness simulation (red line), and $e^{-1/2}$ in the low stickiness simulation.*

Figure 7: **Impulse Response Functions for Taylor Rule versus Average Inflation Targeting**
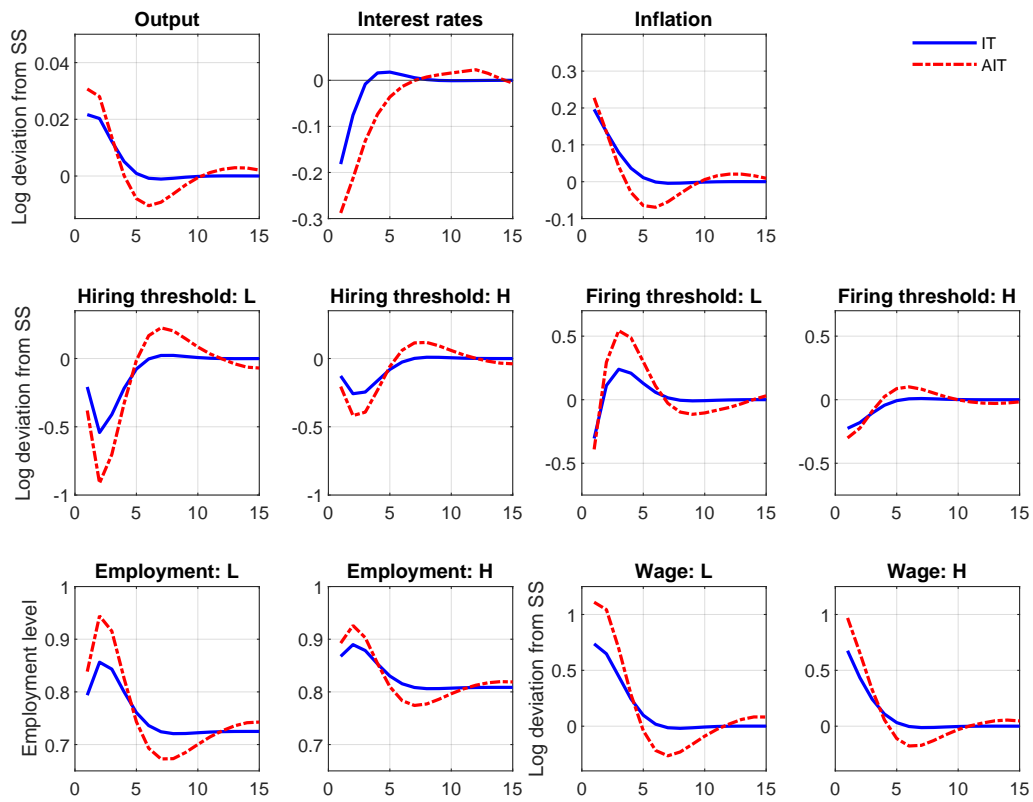


*This figure plots impulse response functions for output, interest rate, inflation, hiring thresholds, firing thresholds, the fractions of workers employed, and wages for high (H) and low (L) type workers. Response functions are plotted for a standard Taylor rule with interest rate smoothing and for a version with average inflation targeting adding eleven lags of inflation.*

Table 1: **Average Labor Force Attachment by Demographic Group, 1990q1–2019q1**

|  | Mean | Standard Error |
|---|---|---|
| Blacks | 56.6% | 0.1 |
| Whites | 62.3% | 0.1 |
|  |  |  |
| Less than High School | 40.3% | 0.1 |
| High School | 58.9% | 0.2 |
| Some College | 68.1% | 0.2 |
| Bachelors Degree | 75.7% | 0.1 |
|  |  |  |
| Female | 55.2% | 0.1 |
| Male | 68.5% | 0.2 |

Data are calculated from statistics reported by the Bureau of Labor Statistics.

Table 2: **Summary Statistics**

|  | N | Mean | SD | p10 | p25 | p50 | p75 | p90 |
|---|---|---|---|---|---|---|---|---|
| Federal Funds Rate | 1,204,974 | 2.32 | 2.25 | 0.09 | 0.16 | 1.52 | 4.81 | 5.42 |
| Monetary Shock | 1,204,974 | -3.73 | 0.93 | -4.58 | -4.57 | -3.70 | -3.59 | -2.19 |
| Emp/Pop | 1,204,974 | 0.67 | 0.14 | 0.49 | 0.58 | 0.67 | 0.77 | 0.86 |
| *Two Year Employment Growth* |  |  |  |  |  |  |  |  |
| Blacks | 513,140 | 10.04 | 21.81 | -12.71 | -2.01 | 8.01 | 18.84 | 33.75 |
| Whites | 1,019,587 | 6.12 | 13.72 | -7.55 | -0.98 | 4.76 | 11.23 | 20.67 |
|  |  |  |  |  |  |  |  |  |
| Less than High School | 753,583 | 2.12 | 14.09 | -12.68 | -5.67 | 0.92 | 8.35 | 17.84 |
| High School | 1,031,445 | 0.60 | 12.54 | -12.09 | -6.08 | -0.59 | 5.69 | 14.18 |
| Some College | 1,039,754 | 0.97 | 12.37 | -11.53 | -5.55 | -0.24 | 5.88 | 14.35 |
| Bachelors Degree | 920,562 | 1.12 | 12.02 | -11.39 | -5.36 | 0.08 | 6.14 | 14.31 |
|  |  |  |  |  |  |  |  |  |
| Female | 1,082,355 | 6.53 | 15.74 | -9.48 | -1.67 | 5.04 | 12.51 | 23.34 |
| Male | 1,155,480 | 7.02 | 15.84 | -8.76 | -1.20 | 5.46 | 12.84 | 23.66 |

This table provides summary statistics for the main variables used in the analysis. The statistics are equal-weighted across MSA-industry-subgroup-quarter cells.

Table 3: **Two-Year Employment Growth and Federal Funds Rate by Labor Market Tightness**

**Panel A: Race**

|  | (1) | (2) |
|---|---|---|
|  | Blacks | Whites |
| Fed Funds Rate × Emp/Pop | -1.09*** | 0.10 |
|  | (0.40) | (0.18) |
|  | [0.00] |  |
| $R^2$ | 0.30 | 0.28 |
| Observations | 511,843 | 1,019,176 |

**Panel B: Education**

|  | (3) | (4) | (5) | (6) |
|---|---|---|---|---|
|  | Less than High School | High School | Some College | Bachelors Degree |
| Fed Funds Rate × Emp/Pop | -0.47** | 0.00 | 0.02 | 0.05 |
|  | (0.20) | (0.17) | (0.16) | (0.17) |
|  | [0.00] | [0.66] | [0.77] |  |
| $R^2$ | 0.30 | 0.26 | 0.26 | 0.27 |
| Observations | 752,685 | 1,030,813 | 1,039,149 | 919,853 |

**Panel C: Sex**

|  | (7) | (8) |
|---|---|---|
|  | Female | Male |
| Fed Funds Rate × Emp/Pop | -0.26 | -0.03 |
|  | (0.18) | (0.20) |
|  | [0.02] |  |
| $R^2$ | 0.28 | 0.24 |
| Observations | 1,081,865 | 1,155,071 |

All Regressions are run at the MSA-industry-quarter level and include MSA-industry fixed effects, industry-quarter fixed effects, and the non-interacted Employment-to-Population ratio (not reported). Standard errors adjusted for clustering at MSA level. p-value of difference from Whites (Panel A), from Bachelors Degree (Panel B) and from males (Panel C) in square brackets. * p<0.10, ** p<0.05, *** p<0.01

Table 4: **Two-Year Employment Growth and Monetary Shocks by Labor Market Tightness**

**Panel A: Race**

|  | (1)<br>Blacks | (2)<br>Whites |
|---|---|---|
| Monetary Shock × Emp/Pop | -2.62**<br>(1.09)<br>[0.00] | 0.11<br>(0.51) |
| $R^2$ | 0.30 | 0.28 |
| Observations | 511,843 | 1,019,176 |

**Panel B: Education**

|  | (3)<br>Less than<br>High School | (4)<br>High School | (5)<br>Some College | (6)<br>Bachelors Degree |
|---|---|---|---|---|
| Monetary Shock × Emp/Pop | -1.39***<br>(0.52)<br>[0.00] | -0.32<br>(0.46)<br>[0.58] | -0.36<br>(0.45)<br>[0.42] | -0.16<br>(0.52) |
| $R^2$ | 0.30 | 0.26 | 0.26 | 0.27 |
| Observations | 752,685 | 1,030,813 | 1,039,149 | 919,853 |

**Panel C: Sex**

|  | (7)<br>Female | (8)<br>Male |
|---|---|---|
| Monetary Shock × Emp/Pop | -0.91*<br>(0.53)<br>[0.07] | -0.45<br>(0.56) |
| $R^2$ | 0.28 | 0.24 |
| Observations | 1,081,865 | 1,155,071 |

All Regressions are run at the MSA-industry-quarter level and include MSA-industry fixed effects, industry-quarter fixed effects, and the non-interacted Employment-to-Population ratio (not reported). Monetary Shock is the accumulated running sum of high frequency innovations in the federal funds future (as in, Kuttner, 2001) from the start of the sample period through each quarter $t$. Standard errors adjusted for clustering at MSA level. p-value of difference from Whites (Panel A), from Bachelors Degree (Panel B) and from males (Panel C) in square brackets. * p<0.10, ** p<0.05, *** p<0.01

Table 5: **Two-Year Employment Growth and Federal Funds Rate by Labor Market Tightness: 2SLS Estimates**

**Panel A: First Stage**

|  | (1) Fed Funds Rate $\times$ Emp/Pop |
| --- | --- |
| Monetary Shock $\times$ Emp/Pop | 2.13*** |
|  | (0.03) |
| $F-statistic$ | 4,984.19 |
| Observations | 511,843 |

**Panel B: Race**

|  | (2) Blacks | (3) Whites |
| --- | --- | --- |
| Fed Funds Rate $\times$ Emp/Pop | -1.23** | 0.05 |
|  | (0.51) | (0.24) |
|  | [0.00] |  |
| $R^2$ | 0.00 | 0.01 |
| Observations | 511,843 | 1,019,176 |

**Panel C: Education**

|  | (4) Less than High School | (5) High School | (6) Some College | (7) Bachelors Degree |
| --- | --- | --- | --- | --- |
| Fed Funds Rate $\times$ Emp/Pop | -0.66*** | -0.15 | -0.17 | -0.08 |
|  | (0.25) | (0.22) | (0.22) | (0.25) |
|  | [0.00] | [0.58] | [0.42] |  |
| $R^2$ | 0.01 | 0.01 | 0.01 | 0.00 |
| Observations | 752,685 | 1,030,813 | 1,039,149 | 919,853 |

**Panel D: Sex**

|  | (8) Female | (9) Male |
| --- | --- | --- |
| Fed Funds Rate $\times$ Emp/Pop | -0.44* | -0.22 |
|  | (0.25) | (0.27) |
|  | [0.07] |  |
| $R^2$ | 0.00 | 0.01 |
| Observations | 1,081,865 | 1,155,071 |

Panel A reports first-stage results of a 2SLS specification which instruments for the interaction between the federal funds rate and the local employment-to-population ratio using the interaction between the monetary shock variable and the local employment-to-population ratio. Monetary Shock is the accumulated running sum of high frequency innovations in the federal funds future (as in, Kuttner, 2001) from the start of the sample period through each quarter $t$. Panels B–D report results of the second stage regressions, which are run at the MSA-industry-quarter level and include MSA-industry fixed effects, industry-quarter fixed effects, and the non-interacted employment-to-population ratio (not reported). Standard errors adjusted for clustering at MSA level. p-value of difference from Whites (Panel B), from Bachelors Degree (Panel C) and from males (Panel D) in square brackets. * p<0.10, ** p<0.05, *** p<0.01

## Table 6: **Calibration Parameters**

*Notes.* This table reports the baseline parameters values.

| | |
|---|---|
| $\beta = 0.99$ | quarterly discount factor |
| $\sigma = 1$ | inverse Intertemporal Elasticity of Substituion |
| $\chi = 4$ | Disutility of working |
| $\mathbb{h} = 0.8$ | Habit formation |
| $\theta = 0.73$ | Calvo parameter |
| $\phi_\pi = 1.24$ | Taylor rule response to interest rate |
| $\phi_y = 0.33/4$ | Taylor rule response to output |
| $\rho_i = 0.7$ | Interest rate smoothing |
| $\rho_\mu = 0.1$ | Interest rate shock persistence |
| $F = 0.25$ | Hiring cost |
| $\delta = 0.05$ | Exogenous separation rate |
| $\bar{a}_h = 0.45$ | Steady state hiring threshold H |
| $\bar{a}_l = 0.45$ | Steady state hiring threshold L |
| $\underline{s} = 0.1$ | Lower bound on support of productivity of high type |
| $\bar{s} = 0.75$ | Upper bound on support of productivity of low type |
| $\gamma = 0.5$ | Share of high types |