Heterogeneous Labor Market Effects of Monetary Policy*

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Abstract

This paper analyzes the heterogeneous effects of monetary policy on workers with different 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. We develop a New Keynesian model with heterogeneous workers that explains these results. The model shows that expansionary monetary shocks lead to larger and more persistent increases in the employment of low attachment populations 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 will especially benefit workers with lower labor force attachment.

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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

1 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 in order to achieve 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 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.

We measure monetary policy using the federal funds rate. To alleviate concerns about the endogeneity of monetary policy, we employ an instrumental variables two-stage least squares (2SLS) approach 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 within a quarter to instrument for the federal funds rate itself. This instrumental variable approach is in the spirit of Gertler and Karadi (2015), who use high frequency monetary shocks as an external instrument within a structural VAR framework.

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, using the 2SLS approach, we find that a standard deviation drop in the federal funds rate increases Black employment growth by 0.55 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 by 0.36 percentage points more in tight labor markets than in slack ones. This ad-

[1] The uninteracted effect of monetary policy on employment growth is not identified in the presence of these time fixed effects, but the differential effect of monetary policy in tight as compared to slack labor markets is identified.

ditional impact of monetary policy in tight labor markets is sizable, corresponding to 11.4% and 36% 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.

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. Instead of interpreting productivity literally, one could think of the heterogeneous worker types as reflecting firms discriminating between workers even in the absence of productivity differences. In each period, firms retain and hire workers with productivity above endogenous thresholds, which are affected by monetary policy.

We show that expansionary monetary policy lowers the hiring and firing thresholds, resulting in greater employment among lower-productivity workers. Our model shows that 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.

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, exhibits a higher tolerance for above-target inflation. 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 seven previous quarters. We show that average inflation targeting results in a more persistent increase in output and more persistent declines in the hiring and firing thresholds. With average inflation targeting, expansionary monetary shocks thus lead to larger and more persistent increases in the employment of lower productivity workers.

The apparent flattening of the Philips curve over the past decades reduces inflationary pressure, altering the tradeoff between output and inflation. We study this phenomenon in the model by varying the degree of price stickiness in the economy. We show that 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 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.

1.1 Related Literature

A small empirical literature studies the distributional effects of monetary policy. Coibion et al. (2017) find that contractionary policy increases inequality in the US. Romer and Romer (1999) show that expansionary monetary policy results in improved conditions for the poor in the short run but the effect might reverse in the long run because of inflationary pressure. Thorbecke (2001), Carpenter and Rodgers III (2004) and Zavodny and Zha (2000) analyze the relation between monetary policy and labor market outcomes across different race categories. Applying VARs and autoregressive distributed lag models to national-level data, they find that expansionary monetary policy shocks reduce unemployment more for blacks than for whites. Empirically, we build on this work but use more granular data and high-frequency shocks for identification. Further, we show how labor market tightness is a key mediating factor for the differential impact of monetary policy. Finally, we develop a New Keynesian model to rationalize our results and perform counterfactual analysis.

Our empirical results also relate to the literature studying differences in the cyclical fluctuation of labor market outcomes across different demographic groups, which shows that the employment of minority workers, less educated workers, and younger workers varies more over the business cycle (see, e.g., Freeman et al. (1973) and Freeman (1990); Clark and Summers (1980); Bound and Freeman (1992), and Elsby et al. (2010)). We study the cyclical fluctuation in employment of different demographic groups with varying levels of labor market attachment, conditional on monetary policy shocks. We focus on the role of labor market tightness as a mediating factor in the transmission of monetary shocks into employment growth. Our results show that demographic groups with lower labor force attachment need tight labor markets to benefit from expansionary policy, whereas the fluctuations of other, more attached demographic groups are independent of tightness.

Several recent papers use micro data to study the effects of monetary policy on real quantities through a mortgage refinancing channel: as nominal interest rates decrease, households refinance their fixed rate mortgages, increasing the amount of their income available for consumption. Beraja et al. (2019) show that this channel leads monetary policy to have differential effects across US regions with different levels of home equity. Wong (2016) shows this channel also leads monetary policy to affect the consumption of younger households more than older ones. Berger et al. (2018) and Eichenbaum et al. (2018) show that the real effects of monetary policy depend on the historical path of interest rates, which determines the share of households that have already refinanced their mortgages.

From a theoretical perspective, our analysis builds on Blanchard and Diamond (1994) and Blanchard (1995), which describe so-called "ranking" effects in labor markets.[2] Similarly, Blanchard and Katz (1997) argue that shifts in labor demand disproportionally affect lower skilled workers because they have a higher elasticity of labor supply. Our model embeds ranking effects in a New Keynesian heterogeneous worker framework. In the model, labor market tightness is a key factor in mediating the effect of monetary policy shocks across worker types. In tight labor markets, monetary policy shocks will have a larger impact on lower productivity workers, whereas, in slack labor markets, the impact on higher productivity workers is predicted to be larger.

[2]See also Blanchard (1996), which discusses ranking effects among long-term versus short-term unemployed, as well as Shimer (1998).

Our work is also related to the vast New Keynesian literature studying the real effect of monetary policy. The standard New Keynesian model typically does not analyze unemployment (see, e.g., Christiano et al. (2005)). Merz (1995) was the first to introduce labor market frictions into business cycle models. 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, 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 (see, e.g, Blanchard and Galí (2010); Faia (2008, 2009)); Gertler et al. (2008); Christiano et al. (2010) and Christiano et al. (2011)). Galí et al. (2012) build on Galí (2011a,b) and allow for market power in the labor market in a representative household model to generate involuntary unemployment in a tractable manner. 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 workers of two levels of efficiency competing for identical jobs with firms screening workers to determine their productivity. Ravenna and Walsh (2012) focuses on understanding how productivity shocks affect the unemployment-inflation tradeoff via a composition effect of the unemployed, whereas we study the effect of exogenous monetary policy on different parts of the productivity distribution. We also relate to Baek (2020) who extends Christiano et al. (2020) and models regular and irregular workers without perfect consumption insurance in a New Keynesian model and derives optimal monetary policy.

Finally, while related to the recent Heterogeneous Agent New Keynesian (HANK) literature, our study focuses on a different source of agent heterogeneity. Studies in the HANK literature (see, e.g., Auclert (2019), Kaplan et al. (2018), Auclert et al. (2020), Bayer et al. (2019), Krueger et al. (2016)) document the role of heterogeneity in the liquidity of households' financial portfolios as a key state variable for the transmission of shocks, and especially monetary policy shocks, when markets are incomplete. The intertemporal substitution channel becomes less relevant as compared to a representative agent framework, and an indirect channel of monetary policy transmission gains importance through income effects. In contrast to these studies, we focus on the impact of heterogeneity in workers' labor market attachment and labor market tightness on the transmission of monetary shocks.

2 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 advantages. 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. 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.

2.1 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, 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 4-digit NAICS industry. Using these data, we calculate for each demographic group, MSA, and industry cell the annual employment growth over the subsequent four quarters $t+1$ to $t+4$. 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

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

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 frequencies. 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 shortly after t, $ff_{t-\Delta t^-,0}$ is the fed funds futures rate just before t, and D is the number of days in the month.[5] The $D/(D-t)$ term adjusts for the fact the federal

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

[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. Due to changes in the policy target on unscheduled meetings, we have six observations with more than one change in a given month. Because these policy moves were not anticipated, they most likely have no major impact on our results. We also exclude intermeeting policy decisions in the baseline analyses.

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 our analysis, 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 2.25%, while the average employment to population ratio is 0.67. The average annual employment growth rate is 4.8% for Blacks and 3.0% for Whites. Employment growth is also more volatile for Blacks than for Whites (standard deviation of 14.1% as compared to 9.1%), which is consistent with Black employment growth being more cyclical.

The average employment growth rate also varies with workers' education and sex. The average annual employment growth rate is twice as high for workers without a high school degree (1.0%) as for those with a bachelor's degree (0.5%). Average growth rates are more similar for men (3.4%) and women (3.2%).

2.2 Results

For each demographic group g, we run the following OLS regression:

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

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 $t+4$ 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, β_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 differentially to variation in monetary policy in tight, as compared to slack, labor markets.[6]

Table 3 presents OLS estimates of equation (3), relating the employment growth rate to the federal funds rate and local labor market tightness. 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, β_1, is nega-

[6]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.

tive, sizable, and statistically significant. It implies that 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 (2.2 percentage point) decrease in the federal funds rate. Our estimate implies that this drop in the federal funds rate is associated with a 0.37 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%).

For Whites, in contrast to Blacks, the β_1 coefficient is much smaller and not statistically significant (column 2). 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 as it does for Blacks, and the difference in the Black and White coefficient estimates is highly statistically significant ($p = 0.015$).

Panel B of Table 3 presents a similar analysis of heterogeneity 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 in column 5, and bachelor's degree holders in column 6.[7] 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 β_1 coefficient implies that a one standard deviation drop in the federal funds rate is associated with a 0.24 percentage point greater growth in employment of these unskilled workers in tight labor markets (90th percentile) than in slack ones (10th percentile).

For workers with greater educational attainment, in contrast, the β_1 coefficients are less than one third of the size it is for unskilled workers and are 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 unskilled workers is statistically different from the three remaining coefficients. For example, the p-value of the difference between

[7] We cannot conduct the analysis at the race-by-education level due to data availability constraints.

the coefficients for those who did not complete high school and those with a bachelor's degree' is 0.007. 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. Among women, reductions in the federal funds rate is associated with greater increases in employment growth in tight labor markets than slack ones (column 7). A one standard deviation drop in the federal funds rate is associated with a growth in female employment that is 0.17 percentage point higher in tight labor markets (90th percentile) than in slack ones (10th percentile). In contrast, the analogous estimate for males is not statistically different than zero.

Even though our analysis is at the MSA level, there is still a concern that developments in the federal funds rate are endogenous and correlated with variables affecting employment growth. Because decreases in the federal funds rate tend to occur in response to deteriorations in the economy, if employment growth in slack labor markets is more pro-cyclical, the coefficients in Table 3 will be biased upwards (i.e., less negative). To alleviate this concern, we examine the effects of unexpected changes in monetary policy, identified using high frequency movements in the federal funds futures rates 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 exercise 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 rerun the baseline specification from regression 3 after replacing the federal funds rate with the monetary shocks variable. 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.

The results using monetary shocks in Tables 4 are qualitatively similar to those using the federal funds rate in Table 3. The implied economic magnitudes of the effect of a one standard deviation change in the monetary policy shock is larger than in the OLS specification. 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; $p < 0.01$), White employment growth does not depend on labor market tightness in a statistically significant manner. The Black coefficient is almost five times the White coefficient, and the difference between them is statistically significant at the 1% level.

Panel B of Table 4 presents results across education levels. The education group least attached to the labor force—workers without a high school diploma—is again more sensitive to monetary policy shock in tight labor markets than in slack ones: The coefficient for those who did not complete high school, reported in column 3, is double that for high school graduates in column 4, those with some college in column 5, and bachelor's degree holders in column 6. The difference between the estimates for the lowest and highest education groups is statistically significant at the 1.1% level.

Panel C of Table 4 reports the reduced form results by sex. The estimates suggest that whereas among women monetary expansions lead to greater employment growth in tighter labor markets, this effect is smaller among men. Although the coefficients in the two columns of Panel C are more similar than in the other dimensions of heterogeneity, the difference between them is still significant at the 10% level.

Finally, to measure the effect of changes in the federal funds rate itself, we run a 2SLS specification in which we use the monetary policy shock variable to instrument for the federal funds rate. Specifically, we instrument 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. Panel A of Table 5 reports the results of the first stage equation:[8]

$$\begin{aligned} FedFunds_t \times Empl/Pop_{m,t-1} = \alpha_1 \times MonetaryShock_t \times Empl/Pop_{m,t-1} + \\ \alpha_2 \times Empl/Pop_{m,t-1} + \theta_{j,m} + \delta_{j,t} + \eta_{j,g,m,t}, \end{aligned} \quad (4)$$

[8]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.

where $MonetaryShock_t$ is the monetary shock variable in quarter t. As Panel A shows, the coefficient of interest, α_1, is positive and highly statistically significant ($p < 0.001$). The first stage F-statistic is 5524, 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 4 for the federal funds rate. Compared to the analogous OLS estimates reported in Table 3, the IV estimates in Table 5 are larger in magnitude (i.e., more negative) and more statistically significant. The difference between the estimates suggests that the covariate of interest $FedFunds_t \times Empl/Pop_{m,t-1}$ is 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 standard deviation drop in the federal funds rate increases Black employment growth by 0.55 percentage points more in tight labor markets (90th percentile) than in slack labor markets (10th percentile). This additional boost is sizable, corresponding to 11.4% of mean Black employment growth over the sample period. In contrast, the 2SLS coefficient for Whites (column 3) is statistically insignificant and less than one-fourth of the Black coefficient, with the difference between the two coefficients statistically significant at the 10% level. The impact of monetary easing on employment growth does not depend on labor market tightness among Whites as it does among Blacks.

Results across education groups are reported in Panel C. Compared to the OLS estimates in Table 3, all of the IV estimates are larger in magnitude and more statistically significant. The coefficient for those who did not complete high school (column 4) remains twice as large as the coefficients for 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 0.011.[9] The point estimate implies that, for workers who did not complete high school, a standard deviation drop in the federal funds rate increases employment growth by 0.36 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 36% of their average annual 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 and more statistically significant, 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 0.27 percentage point higher in tight labor markets (90th percentile) than in slack ones (10th percentile). The coefficient estimate for men is one-third smaller, and the difference between the two coefficients is significant at the 9% 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 low labor market attachment—Blacks, the least educated, and women—the most when labor markets are tight. 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.

[9]The difference between the less-than-high-school coefficient and the coefficients for each of the other two groups with greater educational attainment are also not statistically significant.

3 Model

Our empirical results show that in tight labor markets less attached segments of the labor force are more sensitive to monetary policy shocks. We now develop a model of an economy with heterogeneous workers who differ in their productivity to examine the underpinnings of this empirical regularity and to perform counterfactual analysis. Workers consume output and supply labor to firms. Following Galí (2011b), we assume that 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 use the model to study how monetary policy shocks affect the employment of workers with different types.

3.1 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 A_t and worker-specific productivity $a_{i,t}$ of the period are realized. Aggregate productivity is common knowledge. Individual workers' productivity levels are i.i.d. and 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 enter the period unemployed and those who 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.

3.2 Households

A representative household exists consisting of a continuum of workers with measure 1 indexed by $i \in [0, 1]$. We assume that utility is separable between consumption and disutility of work and that individuals display habit formation over aggregate consumption, which leads macro quantities including output to exhibit humped-shaped responses to shocks. Utility is given by:

$$U_t = \frac{1}{1-\sigma}(C_t - hC_{t-1})^{1-\sigma} - N_t^{\chi}/\chi, \tag{5}$$

where σ is the intertemporal elasticity of substitution, $\chi \geq 1$ is a measure of disutility due to working, and $h > 0$ measures the strength of habit formation. Consumption and the aggregate price index, C_t and P_t , are given by:

$$C_t = \left(\int_0^1 C_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{1-\epsilon}} \tag{6}$$

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

respectively. $C_t(i)$ and $P_t(i)$ are the consumption goods and the price of goods produced by firm i, and ϵ is the elasticity of substitution for differentiated goods.

The demand for (final) good i is given by:

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} C_t, \tag{8}$$

and the household per period budget constraint is:

$$W_t N_t = C_t P_t, \tag{9}$$

where W_t is nominal wages. The first order conditions for labor supply and consumption are given by:

$$\frac{N^{\chi-1}}{Z_t} = \frac{W_t}{P_t} \tag{10}$$

$$Q_t = \beta E_t\left(\frac{Z_{t+1}}{Z_t}\frac{P_t}{P_{t+1}}\right), \tag{11}$$

where

$$Z_t = (C_t - hC_{t-1})^{-\sigma} - h\beta E_t(C_{t+1} - hC_t)^{-\sigma} \tag{12}$$

is the marginal utility of consumption, Q_t is the stochastic discount factor, and β is the subjective time discount factor.

3.3 Labor Market

Denote by $\bar{a}_t$ and $\underline{a}_t$ the productivity thresholds for which a worker is profitable to hire and fire at time t, respectively. Because of hiring costs, $\bar{a}_t > \underline{a}_t$. These thresholds are the model's key dynamic parameters.

The unemployment level at the beginning of the period immediately after exogenous separation takes place, U_t, is given by:

$$U_t = 1 - (1-\delta)N_{t-1}. \tag{13}$$

Total employment, N_t, evolves according to:

$$N_t = (1-\underline{a}_t)(1-\delta)N_{t-1} + H_t, \tag{14}$$

where H_t is hiring in period t. Employment at time t equals employment at time $t-1$, minus exogenous and endogenous separations (governed by δ and $\underline{a}_t$, respectively) plus hiring at time t. For tractability, we assume the labor market is efficient, which implies that the agency interviews all eligible candidates and all workers who exceed the hiring threshold are hired.

The labor participation equations are therefore:

$$H_t = (1 - \bar{a}_t)U_t \tag{15}$$

$$N_t = (1 - \underline{a}_t)(1 - \delta)N_{t-1} + (1 - \bar{a}_t)(1 - (1 - \delta)N_{t-1}), \tag{16}$$

which simplifies to:

$$N_t = (1 - \bar{a}_t) + (1 - \delta)(\bar{a}_t - \underline{a}_t)N_{t-1}. \tag{17}$$

3.4 Hiring

Hiring is outsourced to a third-party agency that interviews workers for the firm. The firm specifies a hiring threshold, $\bar{a}_t$, 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_t. The monetary cost of interviewing a worker is therefore

$$G_t = FW_t. \tag{18}$$

In expectation, the hiring agency needs to conduct more interviews per hire when searching for workers with higher productivity. The agency's expected cost per worker hired is increasing in the hiring threshold $\bar{a}_t$ and equal to $\frac{G_t}{1-\bar{a}_t}$, since the expected number of interviews per hire is $\frac{1}{1-\bar{a}_t}$. Because the market for hiring agencies is perfectly competitive, $\frac{G_t}{1-\bar{a}_t}$ is also the fee that the firm pays to hire workers with productivity above $\bar{a}_t$.

We assume that the hiring agency sends the money it earns to an offshore account; the amount is effectively removed from the economy.

3.5 Intermediate 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 a hiring threshold $\bar{a}_t$ equal to the minimum productivity level for which it is profitable to hire workers. Similarly, in each period, firms set a firing threshold for productivity, below which workers are endogenously separated from firms. Each worker provides time varying i.i.d. productivity ($a_{i,t}$) draws to the firm. For simplicity, let $a_{i,t}$ be distributed with uniform distribution over support $[0,1]$.

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

$$X_t(j) = A_t \psi_t N_t(j), \tag{19}$$

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

We can rewrite $X_t(j)$ as:

$$X_t(j) = A_t(1-\delta)\int_{\underline{a}_t}^{1} a da + A_t \delta \int_{\bar{a}_t}^{1} a da = A_t[(1-\delta)(1-\underline{a}_t^2) + \delta(1-\bar{a}_t^2)]/2. \tag{20}$$

At the firing threshold, $\underline{a}_t$, the firm must be indifferent between firing and not firing the marginal worker. Therefore, to find $\underline{a}_t$, we equate nominal wages with the nominal benefit of retaining the worker (production and option value of keeping the worker, V_t):

$$W_t = P_t^I A_t \underline{a}_t + V_t, \tag{21}$$

where P_t^I is the price index of intermediate goods.

Similarly, at the hiring threshold, $\bar{a}_t$, the firm is indifferent between hiring and not hiring the marginal worker. Therefore, to find $\bar{a}_t$, we equate the total cost of hiring the worker (interviewing costs and wages) with the benefit of hiring the worker (output and option value of keeping the worker):

$$\frac{G_t}{1-\bar{a}_t} + W_t = P_t^I A_t \bar{a}_t + V_t. \tag{22}$$

Note that G represents only the cost of interviewing a worker. The cost of actually hiring the worker is equal to $\frac{G_t}{1-\bar{a}_t}$, since with a higher threshold more workers need to be interviewed per hire. Thus, the cost per interview needs to be divided by $1-\bar{a}_t$. In equation (22), V_t is the option value of hiring workers (and thus not having to pay the interviewing cost next period by retaining the worker if her productivity is above $\underline{a}_{t+1}$). V_t is given recursively by:

$$V_t = \beta(1-\delta)E_t\left\{\frac{Z_{t+1}}{Z_t}[(1-\underline{a}_{t+1})(G_{t+1}+V_{t+1})\right\}. \tag{23}$$

3.6 Characterizing Intermediate Firms

We assume firms have all the bargaining power. Hence, they only need to pay a wage that makes workers willing to participate in the labor force (see equation (10)). 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, there is no option value from being hired and workers always search and work if the participation condition is satisfied.

For simplicity, we focus only on one period ahead for the option value because the probability of worker retention beyond one period is small given i.i.d productivity draws and exogenous separation:

$$V_t = \beta(1-\delta)E_t\left\{\frac{Z_{t+1}}{Z_t}(1-\underline{a}_{t+1})(G_{t+1})\right\}. \tag{24}$$

Equations (21) and (24) imply:

$$1 = P_t^I \frac{A_t}{W_t}\underline{a}_t + \beta(1-\delta)E_t\left\{\frac{Z_{t+1}}{Z_t}(1-\underline{a}_{t+1})\frac{G_{t+1}}{W_t}\right\} \tag{25}$$

Furthermore, from the workers' labor-wage tradeoff we have:

$$\frac{Z_{t+1}}{Z_t}\frac{W_{t+1}}{W_t} = \frac{N^{\chi}_{t+1}P_{t+1}}{N^{\chi}_t P_t}. \tag{26}$$

Using equation (26) in the option value (equation (25)), we obtain:

$$P^I_t \frac{A_t}{W_t}\underline{a}_t = \left[1 - \beta(1-\delta)E_t\left(\frac{P_{t+1}N^{\chi}_{t+1}}{P_t N^{\chi}_t}F\right)\right] \tag{27}$$

Finally, to characterize $\bar{a}_t$, observe that the difference in the productivity of workers at the two thresholds (equations (21) and (22)) is simply the hiring cost:

$$\frac{G_t}{1-\bar{a}_t} = P^I_t A_t(\bar{a}_t - \underline{a}_t). \tag{28}$$

3.7 Final Firms

We assume there is a continuum of final firms distributed on the unit interval that produce varieties of differentiated products in monopolistically competitive markets using identical technology:

$$Y_t(i) = X_t(i) \tag{29}$$

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. Define the optimal markup implicitly as:

$$P^*_t = \frac{\epsilon}{\epsilon - 1}P^I_t, \tag{30}$$

where ϵ is the elasticity of demand.

We follow Walsh (2005) and Blanchard and Galí (2010) and introduce final firms to avoid an interaction between wage and price setting. The real marginal cost of final firms is:

$$MC_t = \frac{P^I_t}{P_t}. \tag{31}$$

Market clearing dictates:

$$Y_t = C_t, \tag{32}$$

because we assume for simplicity that money paid to hiring agencies is sent to off-shore accounts (to avoid a wedge between Y and C).

Suppose only a measure θ of final firms can reset their price at time t. Hence, the aggregate price level satisfies:

$$P_t = ((1-\theta)(P_t^*)^{1-\epsilon}) + \theta(P_{t-1})^{1-\epsilon})^{\frac{1}{1-\epsilon}}. \tag{33}$$

A firm able to reset prices in period t will do so according to:

$$E_t\left\{\sum_{l=0}^{\infty}\theta^l Q_{t,t+l}Y_{t,t+l|t}\left(P_t^* - \frac{\epsilon}{1-\epsilon}P_{t+l}MC_{t+k}\right)\right\} = 0. \tag{34}$$

Let p_t, p_t^i and π_t be the log linearized value for P_t, P_t^I and inflation, $\Pi_t = P_t/P_{t-1}$, respectively. Then the New Keynesian Philips Curve (in log-linearized terms) given by:

$$\pi_t = \beta E_t[\pi_{t+1}] + \lambda(p_t^i - p_t), \tag{35}$$

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

3.8 Monetary Policy

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

$$\begin{aligned} i_t^* &= \phi_\pi \pi_t + \phi_y y_t + \mu_t \\ i_t &= (1-\rho_i)i_t^* + \rho_i i_{t-1} \\ \mu_t &= \rho_\mu \mu_{t-1} + \epsilon_t, \end{aligned} \tag{36}$$

where ϕ_π and ϕ_y are the coefficients in the Taylor rule on log-linearized inflation π and output y, respectively. Furthermore, the parameters ρ_i and ρ_{mu} modulate the degree of policy smoothing in nominal interest rates and persistence in interest rate shocks, respectively and ϵ_i is an i.i.d. monetary policy innovation.

3.9 Steady State and Log-Linearized System

Now, we write out the full log-linearized system. We denote with lower case letters the log-linearized versions of the variables in capital letters with the following exceptions: $\hat{A}_t, \hat{a}_t, \hat{\alpha}_t$ are the log linearization of $A_t, \bar{a}_t, \underline{a}_t$, respectively. Furthermore, let $\bar{a}$, $\underline{a}$ be the steady state levels of $\bar{a}_t$ and $\underline{a}_t$, respectively.

Share of workers employed (equation (17)):

$$n_t = -\left(\frac{1-(1-\delta)(1-\underline{a})}{(1-\bar{a})}\right)\bar{a}\hat{a}_t - (1-\delta)\underline{a}\hat{\alpha}_t + (1-\delta)(\bar{a}-\underline{a})n_{t-1} \tag{37}$$

Marginal utility (equation (12)):

$$z_t = \frac{-\sigma}{(1-h)(1-h\beta)}((c_t - hc_{t-1}) - h\beta(c_{t+1} - hc_t)) \tag{38}$$

First-order condition for consumption:

$$c_t = \frac{h}{1+h^2\beta}c_{t-1} + \frac{h}{1+h^2\beta}\beta E_t[c_{t+1}] - \frac{(1-h)(1-h\beta)}{\sigma(1+h^2\beta)}E_t[\sum_{j=1}^{\infty}(i_t - E_t\pi_{t+1})] \tag{39}$$

Inflation:

$$\pi_t = (p_t - p_{t-1}) \tag{40}$$

Wage rate (equation (10)):

$$w_t = -\chi n_t - z_t + p_t \tag{41}$$

Cutoff determination of the firing threshold (equation (27)):

$$\frac{-\beta(1-\delta)F\left(\pi_{t+1}+\chi n_{t+1}-\chi n_t\right)}{1-\beta(1-\delta)F}-\hat{\alpha}_t=p_t^i+\hat{A}_t-w_t, \tag{42}$$

Relation between hiring and firing thresholds (Equation 28):

$$w_t=p_i^t+\hat{A}_t+\frac{\bar{a}\hat{a}_t-\underline{a}\hat{\alpha}_t-2\bar{a}^2\hat{a}_t+\bar{a}\underline{a}(\hat{a}_t-\hat{\alpha}_t)}{(\bar{a}-\underline{a})(1-\bar{a})} \tag{43}$$

Market clearing (equation (32)):

$$y_t=c_t \tag{44}$$

Output follows from aggregation of equation (20), applying (32):

$$y_t=\hat{A}_t-2\frac{\delta\bar{a}^2\cdot\hat{a}_t+(1-\delta)\underline{a}^2\cdot\hat{\alpha}_t}{(1-\delta)(1-\underline{a}^2)+\delta(1-\bar{a}^2)} \tag{45}$$

Finally, the log linearized model is closed with the New Keynesian Philips Curve (equation (35)) and the interest rate rule (equation (37)):

$$\begin{aligned}\pi_t&=\beta E_t[\pi_{t+1}]+\lambda(p_t^i-p_t)\\ i_t^*&=\phi_\pi\pi_t+\phi_y y+\mu_t\\ i_t&=(1-\rho_i)i_t^*+\rho_i i_{t-1}\end{aligned}$$

4 Numerical Example and Model Simulations

We calibrate the model at the quarterly frequency using parameters in Table 6. The preference parameters are standard; the average quarterly degree of price stickiness θ is 0.73, implying an average price spell duration of 1.4 quarters, consistent with evidence from microdata (Weber (2015) and Gorodnichenko and Weber (2016)); and the monetary policy specification and shock persistence parameter follow Coibion and Gorodnichenko (2012) and Pasten et al. (2019). We provide extensive robustness checks for other parameter values such as the steady-state hiring threshold $\bar{a}$, which equals 0.5 in our baseline calibration. The Bureau of Labor Statistics estimates the total separation of workers is 0.45 per year in 2019 using JOLTS. We thus choose a value for exogenous separations of 0.1 per quarter to leave room for the incidence of endogenous separation .

Figure 1 reports impulse response functions (IRFs) for output, the hiring threshold $\bar{a}_t$, the firing threshold $\underline{a}_t$, the wage, the nominal interest rate, and inflation to a one-standard deviation expansionary monetary policy shock. For each of these variables, IRFs are plotted for three different levels of the steady state hiring threshold, $\bar{a} \in \{0.3, 0.5, 0.7\}$. We interpret lower steady-state hiring thresholds as tighter labor markets.

In the baseline calibration, we see that an expansionary monetary policy surprise results in a humped-shaped increase in output, an increase in wages on impact, higher inflation, and a somewhat persistent decline in both the hiring and firing thresholds. The lower hiring and firing thresholds imply that an expansionary monetary policy shock results in more workers of lower productivity being hired and fewer such workers being fired. These effects first build up over time before the thresholds converge back to their steady state levels. In the model, loose monetary policy thus particularly benefits lower skilled workers—i.e. those with low a_i—by increasing their employment levels. We stress again that worker productivity, a_i, can be interpreted as capturing firms' *perception* of productivity, or alternatively, as a measure of productivity net of discrimination effects. For brevity, in the following we discuss movements in the hiring and firing thresholds in terms of worker skills.

The calibration in Figure 1 further shows that at lower steady-state levels of the hiring and firing thresholds—i.e., in tighter labor markets—a monetary policy shock leads to larger and more persistent declines in the hiring and firing thresholds. Hence, consistent with our empirical results, we find that tight labor markets disproportionally benefit workers with lower skill levels. This occurs for two reasons. First, in tighter labor markets, the marginal workers who join the labor force in response to the monetary shock are less skilled. This is a straightforward ranking effect similar to Blanchard and Diamond (1994), whereby when filling vacancies, firms begin by hiring higher skilled 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, $\frac{G_t}{1-\bar{a}_t}$, is lower in tighter labor markets, leading a monetary shock to have a larger effect on the hiring threshold.[10]

The Federal Reserve Board announced at the annual 2020 Economic Policy Symposium in Jackson Hole a change in its monetary policy objective from strict to average inflation targeting. Chairman Powell explained that the change seeks to increase the steady state employment of workers with lower labor force attachment, including women and minorities. This change translates into lower levels of $\bar{a}$ and $\underline{a}$ in our model. The IRFs in Figure 1 suggest that the new monetary policy regime not only increases the steady state employment of women and minorities but also makes their employment more responsive to monetary expansions.

Another way to see that employment of workers with low values of a_i are more sensitive to monetary policy when labor markets are tight is to plot the fraction of employed workers for different partitions of the skill distribution. Figure 2 plots the hiring threshold in levels (rather than in deviations from steady state), as well as the fraction of workers that are employed for terciles of the worker productivity distribution. The figure presents these plots for three different levels of labor market tightness: a steady state hiring threshold of 0.3 (tight labor market), 0.5 (baseline), and 0.7 (slack labor market).

The top panel shows that the hiring threshold is most sensitive to expansionary monetary policy when labor markets are tight. This hiring threshold decreases from a steady state value of 0.3 to 0.11 before converging back to its initial level. In contrast, in the baseline labor market tightness case, the threshold decreases from 0.5 to 0.38 before returning to the steady-state value. Finally, in slack labor markets, the hiring threshold moves from 0.7 to only 0.62 before returning to its starting value.

The bottom three panels of the figure examine employment rates over terciles of the worker productivity distribution. For simplicity and to directly map these plots into the top panel, we ignore effects originating from the firing threshold and only plot the fraction of workers employed for the different hiring thresholds. We can see when labor markets are tight (($\bar{a}_i = 0.3$), employment of workers in the low tercile of productivity (below 1/3) is quite sensitive to the monetary expansion. In contrast,

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

workers in the top and medium terciles of the productivity distribution are fully employed in this tight labor market scenario, and their employment rates are insensitive to the monetary expansion.

When labor markets are slack ($\bar{a}_i = 0.7$), low productivity workers remain unemployed throughout the monetary expansion, employment of workers in the medium tercile respond moderately to the expansion, while workers in the high tercile of productivity remain fully employed.

Finally, at the baseline level of market tightness ($\bar{a}_i = 0.5$), the monetary expansion affects employment rates of workers in the middle tercile of productivity (between 1/3 to 2/3), whereas employment rates of the high and low terciles of worker productivity are unaffected; the former are at full employment, whereas the latter are not employed.

We next analyze various comparative statics with respect to the conduct of monetary policy. To examine the effects of the Federal Reserve Board's 2020 policy change to a symmetric (or average) inflation target, Figure 3 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 inflation rate of the current and seven lags of inflation, following Svensson (2020). Consistent with the Federal Reserve Board's motivation to change their policy rule, we find that average inflation targeting results in a more persistent increase in output, a more persistent decline in the hiring and firing thresholds, as well as a higher average inflation rate compared to the standard Taylor rule. Note that because steady state inflation in the model is zero, the expansionary effect of average inflation targeting only kicks in after a few periods. If inflation had a positive trend, then average inflation targeting would have a more expansionary effect on impact.

Figure 4 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. Monetary policy that more aggressively lowers interest rates has the potential to help workers who are normally forced to the sidelines become employed.

The slope of the Philips curve also affects these relations. After recessions, central banks often start increasing interest rates preemptively to reduce inflationary pressure. During the recovery from the Great Recession of 2008/9, however, the Phillips curve was rather flat: inflation consistently remained below target despite tight labor markets and historically low unemployment rates.[11] Critics argue 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.[12]

We model a flatter Phillips curve by increasing the degree of price stickiness in our model economy. Figure 5 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. Importantly, when price stickiness is high, a monetary expansion results also in larger decreases in the hiring and firing thresholds. With a flatter Philips curve, the central bank is able to keep interest rates lower for longer, allowing monetary expansions to help marginal workers enter and remain in the work force.

Taken together, these counterfactual exercises suggests that the the Federal Reserve's new average inflation targeting framework increases the employment of workers with less labor force attachment. Furthermore, the recent flatness of the Philips curve magnifies this beneficial effect of monetary policy on less attached segments of the labor force.

5 Concluding Remarks

Expansionary monetary policy has heterogeneous effects on the labor force. We show that exogenous expansionary monetary policy especially benefits the employment of workers with weak labor force attachment in tight labor markets more than it does in

[11] See, for example, Simon et al. (2013).

[12] See "How the Fed will respond to the COVID-19 recession in an era of low rates and low inflation".

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.

Using a New Keynesian model with workers of heterogeneous types, we show that a monetary policy that follows an average inflation targeting rule benefits less-attached workers in particular. By keeping rates low for longer, more less-attached workers become employed. 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 allows the labor markets to tighten significantly, would facilitate robust employment growth among less-attached workers. As such, our findings imply that the Federal Reserve's recent change in the conduct of monetary policy from strict to average inflation targeting will benefit employment of female, minority, and low skilled workers. We emphasize, though, that our study does not enable statements about welfare nor an analysis of optimal monetary policy. Both are left for future work.

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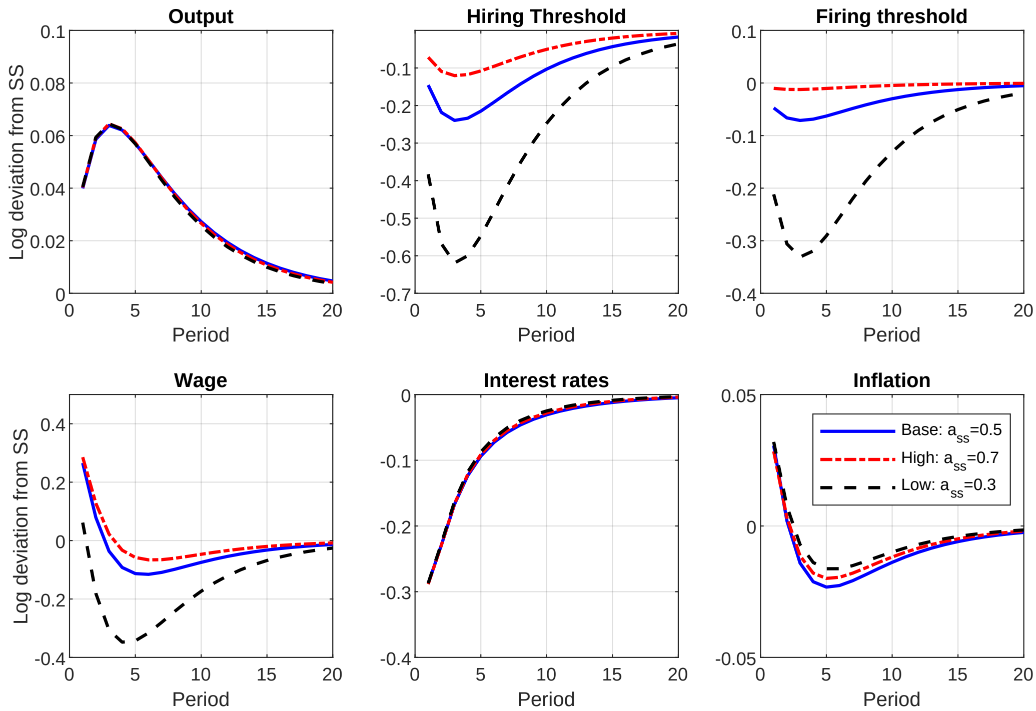
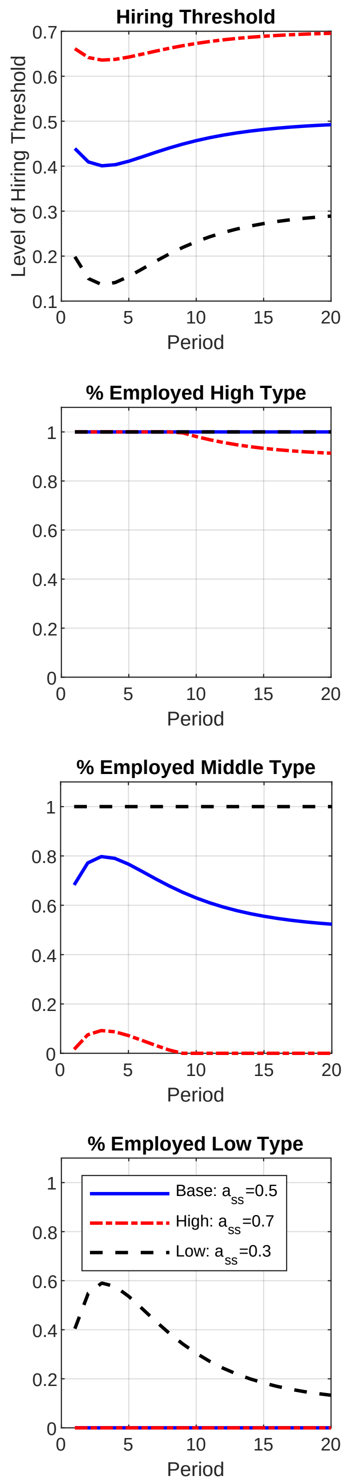
Figure 1: **Impulse Response Functions for different Steady-State Thresholds**



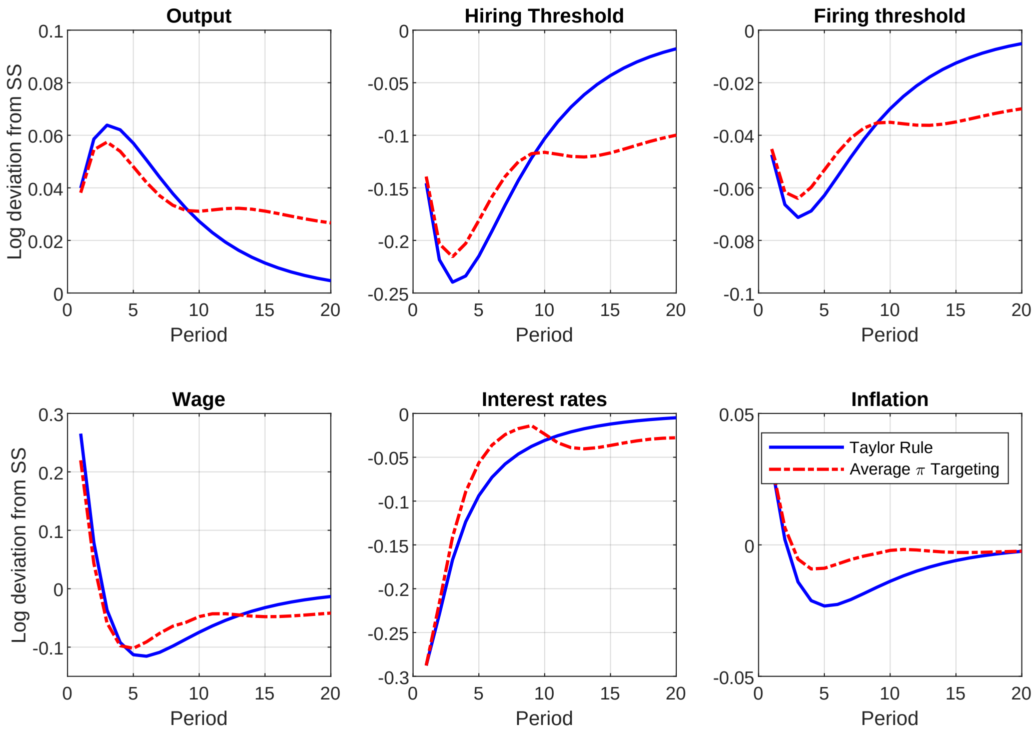
This figure plots impulse response functions for output, hiring threshold, firing threshold, wage, interest rates, and inflation for different levels of the steady-state hiring threshold varying $\bar{a}_{ss}$ from a baseline of 0.5 to 0.3 and 0.7.

Figure 2: **Employment by Labor Type**



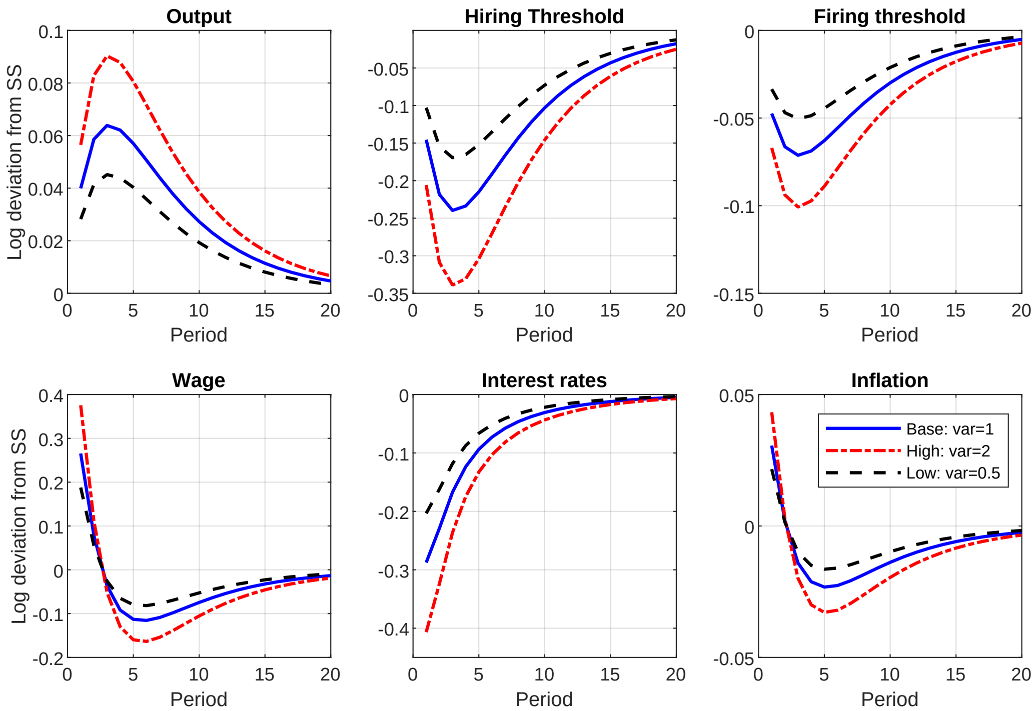
This figure plots impulse response functions for the hiring threshold in levels, and the employment for tertiles of the worker productivity distribution for different levels of the steady-state hiring threshold varying $\bar{a}_{ss}$ from a baseline of 0.5 to 0.3 and 0.7.

Figure 3: **Impulse Response Functions for Taylor Rule versus Average Inflation Targeting**



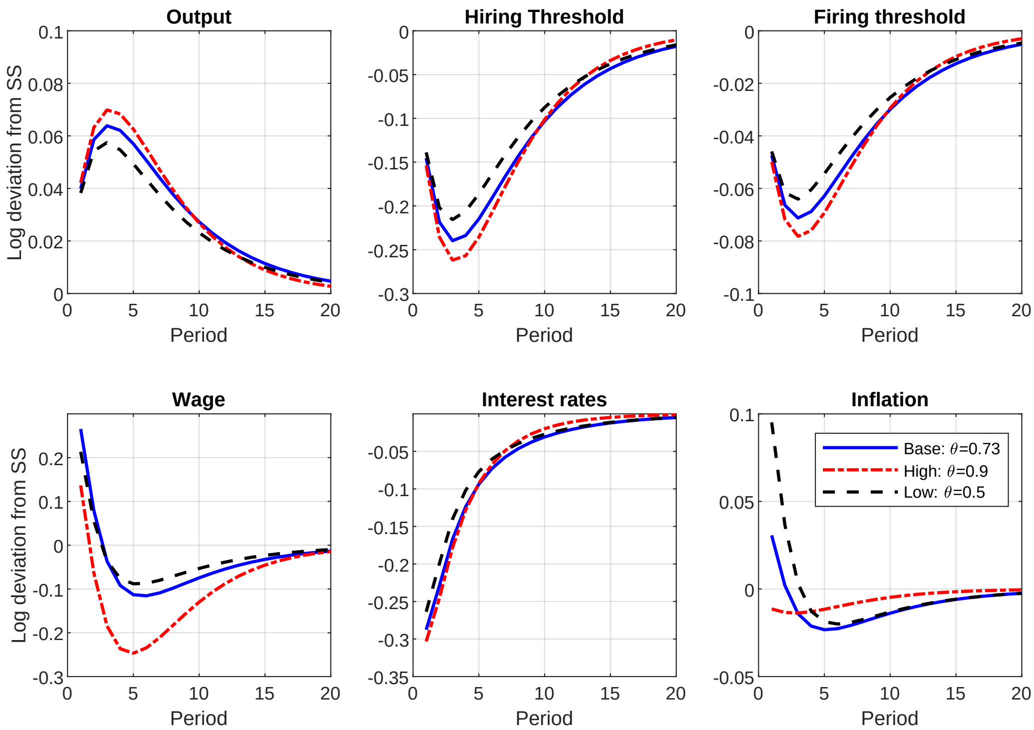
This figure plots impulse response functions for output, hiring threshold, firing threshold, wage, interest rates, and inflation for a standard Taylor rule with interest rate smoothing and a version with average inflation targeting adding seven lags of inflation.

Figure 4: **Impulse Response Functions for Different Shocks Sizes**



This figure plots impulse response functions for output, hiring threshold, firing threshold, wage, interest rates, and inflation for different levels monetary policy shocks, varying the value of $var(\epsilon^i) = 1$ *to 0.5 and 2.*

Figure 5: **Impulse Response Functions for different Degrees of Price Stickiness**



This figure plots impulse response functions for output, hiring threshold, firing threshold, wage, interest rates, and inflation for different levels price stickiness, varying the baseline value of $\theta = 0.73$ *between 0.5 and 0.9.*

Table 1: **Average Labor Force Attachment by Demographic Group**

	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

Average Labor Force Attachment by Demographic Group, 1990q1–2019q1

Table 2: **Summary Statistics**

	N	Mean	SD	p10	p25	p50	p75	p90
Federal Funds Rate	1,282,229	2.25	2.20	0.10	0.16	1.26	4.74	5.42
Monetary Shock	1,282,229	-3.79	0.93	-4.67	-4.58	-3.81	-3.59	-2.19
Emp/Pop	1,282,229	0.67	0.15	0.49	0.58	0.67	0.77	0.86
Annual Employment Growth								
Blacks	548,411	4.84	14.10	-9.80	-2.33	3.87	10.51	19.85
Whites	1,113,617	2.97	8.81	-5.73	-1.23	2.34	6.27	12.12
Less than High School	802,776	0.99	9.32	-8.82	-3.78	0.49	5.12	11.11
High School	1,094,130	0.24	8.26	-8.14	-3.83	-0.27	3.60	9.04
Some College	1,103,118	0.43	8.12	-7.79	-3.54	-0.09	3.78	9.08
Bachelors Degree	977,640	0.49	7.90	-7.68	-3.46	0.00	3.76	9.01
Female	1,147,933	3.15	9.98	-7.00	-1.70	2.50	7.02	13.69
Male	1,226,101	3.37	10.18	-6.82	-1.56	2.66	7.24	14.02

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: **Employment Growth and Federal Funds Rate, by Labor Market Tightness**

Panel A: Race

	(1) Blacks	(2) Whites
Fed Funds Rate X Emp/Pop	-0.45**	-0.06
	(0.21)	(0.10)
	[0.015]	
R^2	0.20	0.18
Observations	546,879	1,113,245

Panel B: Education

	(3) Less than High School	(4) High School	(5) Some College	(6) Bachelors Degree
Fed Funds Rate X Emp/Pop	-0.29**	-0.08	-0.08	-0.09
	(0.11)	(0.09)	(0.09)	(0.10)
	[0.01]	[0.88]	[0.86]	
R^2	0.19	0.17	0.16	0.17
Observations	801,810	1,093,531	1,102,549	976,950

Panel C: Sex

	(7) Female	(8) Male
Fed Funds Rate X Emp/Pop	-0.21*	-0.11
	(0.107)	(0.11)
	[0.05]	
R^2	0.17	0.15
Observations	1,147,470	1,225,714

I

All Regressions 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 Nonhispanic 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: **Employment Growth and Monetary Shocks, by Labor Market Tightness: Reduced Form**

Panel A: Race

	(1) Blacks	(2) Whites
Monetary Shock X Emp/Pop	-1.39***	-0.29
	(0.53)	(0.24)
	[0.01]	
R^2	0.20	0.18
Observations	546,879	1,113,245

Panel B: Education

	(3) Less than High School	(4) High School	(5) Some College	(6) Bachelors Degree
Monetary Shock X Emp/Pop	-0.90***	-0.40*	-0.42*	-0.44*
	(0.26)	(0.23)	(0.22)	(0.26)
	[0.01]	[0.81]	[0.89]	
R^2	0.19	0.17	0.16	0.17
Observations	801,810	1,093,531	1,102,549	976,950

Panel C: Sex

	(7) Female	(8) Male
Monetary Shock X Emp/Pop	-0.67***	-0.46*
	(0.26)	(0.27)
	[0.09]	
R^2	0.17	0.15
Observations	1,147,470	1,225,714

All Regressions 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 Nonhispanic 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: **Employment Growth and Federal Funds Rate, by Labor Market Tightness: Instrumental Variables**

Panel A: First Stage

	(1) Fed Funds Rate × Emp/Pop
Monetary Shock X Emp/Pop	2.04***
	(0.027)
$F - statistic$	5523.85
Observations	546,879

Panel B: Race

	(2) Blacks	(3) Whites
Fed Funds Rate X Emp/Pop	-0.68***	-0.15
	(0.26)	(0.12)
	[0.10]	
R^2	0.00	0.01
Observations	546,879	1,113,245

Panel C: Education

	(4) Less than High School	(5) High School	(6) Some College	(7) Bachelors Degree
Fed Funds Rate X Emp/Pop	-0.44***	-0.20*	-0.21*	-0.22*
	(0.13)	(0.11)	(0.11)	(0.13)
	[0.01]	[0.81]	[0.90]	
R^2	0.01	0.01	0.00	0.00
Observations	801,810	1,093,531	1,102,549	976,950

Panel D: Sex

	(8) Female	(9) Male
Fed Funds Rate X Emp/Pop	-0.33***	-0.23 *
	(0.13)	(0.13)
	[0.09]	
R^2	0.00	0.01
Observations	1,147,470	1,225,714

All Regressions in Panels B–D 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 Nonhispanic 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 6: **Calibration Parameters**

Notes. This table reports the baseline parameters values.

$\beta = 0.99$	quarterly discount factor
$\sigma = 1$	inverse Intertemporal Elasticity of Substituion
$\theta = .73$	Calvo parameter
$\phi_\pi = 1.24$	Taylor rule response to interest rate
$\phi_y = 0.33/4$	Taylor rule response to output
$\rho_i = 0.7$	Int. rate smoothing
$\rho_\mu = 0.1$	Shock persistence: int rate
$F = 0.25$	Hiring cost
$\chi = 4$	Disutility of working
$\delta = 0.1$	Exogenous separation
$\bar{a} = 0.5$	Steady state hiring threshold
h = 0.75	Habit formation